ECONOMIC PAPERS ON KENTUCKY GEOLOGY

WILLARD ROUSE JILLSON

The

Kentucky Geological Survey

WILLARD ROUSE JILLSON
DIRECTOR AND STATE GEOLOGIST

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Economic Papers on Kentucky Geology

1921

THE BEAUTIFUL OHIO.

No less important and beautiful today after three hundred years of service as a great artery of trade and passage, than it was to the sturdy pioneer, the Ohio River—Kentucky's own from Catlettsburg to Cairo—is at once our northern boundary and our most majestic waterway. It finds its slow meandering course between great Commonwealths, now splashing lightly against a towering cliff of the Coal Measures, now washing the flag-stone wharfs of great industrial cities, and again losing itself in labyrinthine channels between low Quaternary islands of emerald flanked by countless corn rows, quiet pastures, and happy homesteads. In this view one is looking down stream at Cloverport, Breckinridge County. See Paper No. VI, River and Forest Trails of Western Kentucky.

ECONOMIC PAPERS ON KENTUCKY GEOLOGY

An Indexed Collection of Thirteen Short Papers and Reports on the Geology and Special Occurrence of Oil and Gas, Oil Shale, Asphalt Rock, and Fluorspar Within the Commonwealth

BY

WILLARD ROUSE JILLSON
DIRECTOR AND STATE GEOLOGIST

Author of

THE OIL AND GAS RESOURCES OF KENTUCKY.
CONTRIBUTIONS TO KENTUCKY GEOLOGY.
ETC.

Illustrated with 115 Photographs Maps and Diagrams

FIRST EDITION

THE KENTUCKY GEOLOGICAL SURVEY

FRANKFORT, KY.

1921

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FRANKFORT, KENTUCKY

To My
MOTHER
In Recognition of a Wise Guidance
Through My Youth
This Book is
Dedicated.

AUTHOR'S PREFACE

This is a day of rapidly developing mineral resources. Discoveries of new applications of well known mineral products, as well as the development of a great list of very valuable by-products from formerly waste materials, has led to intensive and detailed examination, and re-examination of the various mineral deposits in the rocks of the earth's crust. Approximate valuations of the quantity and quality of our mineral resources, always an item of interest, has now in the light of steadily increased demand along some lines, become one of vital concern. Conservationists of all types have now the attention of the general public as they disclose the practical limits of our industrial and domestic mineral resource necessities of oil, gas, coal, etc.

With a view of throwing more light on the geological occurrence, present day quantitative reserve and industrial development of several of the most important mineral resources of Kentucky, the papers and reports herewith presented have been written by the State Geologist based on personal field examinations in the performance of his official duties during the present year. All photographs, production curves, diagrams, etc., unless otherwise noted have been made by the writer personally, and this work has been done since the reorganization of the Kentucky Geological Survey in April, 1920. It is sincerely hoped that the informative material contained within these pages will be of material assistance to all who are interested in our mineral resource conservation and development. This book is issued by the Kentucky Geological Survey as Volume 2, of Series 6, in an edition of 2,000 cloth bound, and may be had upon request for 20 cents postage.

W. R. Jillson

Director and State Geologist.

Old State Capitol,
Frankfort, Kentucky.
March 1, 1921.

CONTENTS

ILLUSTRATIONS.

Economic Papers on Kentucky Geology

ILLUSTRATIONS.

Economic Papers on Kentucky Geology

I.

A PRELIMINARY REPORT ON THE OIL SHALES OF KENTUCKY.

The rapid drilling up of the known oil pools of the United States, New Mexico and Canada, and the great difficulty and infrequency with which new pools are brought in, has within the last year or two turned the eyes of capitalists generally to the possibilities of the commercial exploitation of oil shales in this and other states. The fact that crude oil, gases, and other useful materials could be secured by destructive and similar methods of distillation or retorting of certain bituminous shales has been well known for a great many years. Within the last few years an increasingly large number of private and public examinations

SEVENTY-FIVE FEET OF OIL SHALE.
The black Chattanooga Shale is cut on the John Everman farm by the Louisville and Nashville Railroad about three miles west of Clay City, Powell County, Ky.

have been made on the oil shales of Kentucky, Tennessee, Indiana and Ohio in the Eastern United States; and in Colorado, Utah and Wyoming in the Western United States.

It now appears as a result of these investigations that while the Western shales show a much higher oil content in gallons per

ton (50 to 80 gallons per ton), the oil shales of the Eastern United States with a smaller oil content (varying from 8 to 30 gallons per ton), bid fair to compete on equal or even better terms of commercialization, due to their location in close proximity to the center of the consuming population of the United States.

In Kentucky three separate and easily recognizable bituminous shales or groups of shales are recognized. First of these proceeding downward in order of super-position is a group of shales found in the Pottsville (Pennsylvanian) at various horizons in the Eastern and the Western Kentucky Coal Fields. These shales are generally thin, varying from one to five feet.

and are not considered at present of commercial importance. Distillation records of representative samples are herewith appended.

The second, or next lower bituminous shale, is the Sunbury, which occurs toward the base of the Waverly (Mississippian). The Sunbury shale varies from four feet in Powell county to 16 1-4 feet in Rowan county. At Vanceburg, on the Ohio river, in Lewis county, it is 15 feet thick, and was worked for its oil or paraffin content a number of years ago. The Sunbury shale is considered in some locations, at least, to be a commercial possibility at the present time.

The third and lowest oil shale of present day commercial importance in this State is the Chattanooga or Ohio black shale (Upper Devonian). This shale varies from 20 to 45 feet in thickness, generally, along its outcrop which occurs as a narrow belt around the central Blue Grass section of this State, in the Cumberland river valley, and some adjacent minor watercourses. It outcrops in 33 counties in Kentucky and underlies the major portion of the State with the exception of the Blue Grass, from which it has been denuded, and perhaps "The Purchase," where, if it occurs, it would be found at great depths.

A SPLENDID BLACK SHALE OUTCROP.
The view is on the T. B. Ware farm in the cut of the Louisville and Nashville Railroad about three miles west of Clay City, Powell County, Ky.

It has been computed that the area of outcrop of the Devonian black shale in Kentucky is 1,018 square miles, or 651,520 acres. The area not workable due to too advanced exposure is placed at 254 square miles, or 162,560 acres. Allowing approximately 1,000 feet as the outside limit of stripping of cover from outcrop, a total of 953 square miles, or 609,920 acres, is found available for the purpose of industrial operation. The table listing these various areas in the form in which they were computed is given herewith:

COMPUTED AREAS OF CHATTANOOGA BLACK SHALE IN KENTUCKY.

	Area of Outcrop		Area Not Workable		Area Workable, 1/5 Mile Beyond Edge of Outcrop		Sectional Totals Workable	
Section	Sq.Mi.	Acres	Sq.Mi.	Acres	Sq.Mi.	Acres	Sq.Mi.	Acres
Western[1]	511	327,040	128	81,920	54	34,560	437	279,680
Eastern[2]	365	233,600	91	58,240	61	39,040	335	214,400
Southern[3]	142	90,880	35	22,400	74	47,360	181	115,840
Totals	1,018	651,520	254	162,560	189	120,960	953	609,920

[1]Area west and northwest of Stanford. [2]Area east and northeast of Stanford. [3]Area generally south and southwest of Stanford, including a part of the Cumberland River Valley and adjacent water sheds.

Destructive distillation tests have been carried forward on 19 samples of the Devonian black shale and two of the Pennsylvanian black shale, with the result that Taylor county shows the highest oil content of 27.75 gallons per short ton, and Rockcastle county the lowest, with 8 gallons per short ton. Other methods of distillation of the shale might increase the recoverable oil content of the shale in the sampled localities. Some private investigators report as high as 42 gallons to the ton, but this amount is not herewith authenticated for Devonian shale

FIRST KENTUCKY OIL SHALE OPERATION.

The Devon Shale Products Company has now under way the grading preparatory to the erection of their plant at about one mile west of Clay City, Powell County, Ky. This company has 424 acres that will average 80 feet in thickness on the Red River and $\frac{3}{8}$ mile from the Louisville and Nashville Railroad.

though it is a distinct possibility in the cannel-shales of the Pottsville. The table showing the tests is appended. Computations based on the area of commercially important outcrop as given above totals 953 square miles, or 609,920 acres. Using

BLACK SHALE AT ARGYLE.

The view shows a natural exposure of seventy-five feet of black Chattanooga Shale on the A. M. Morehead farm.

the average oil content of 16.08 gallons per ton, gives a possible recoverable quantity of oil of 12,308,217,065 barrels. Allowing a possible profit of $5.00 per barrel on the total operation, including mining and distillation of the shales, and the manufacture of the various by-products, the net value of the crude oil locked in the Devonian black shale amounts to $61,901,085,305.

While the figures as given herewith are intended to be conservative, it is realized that they are in fact very large. In reviewing the possibilities of the commercialization of the Kentucky oil shales, it will be well if the inexperienced will recall that the tarry oil as first recovered from the shale is not salable to any crude oil pipe line. The production of shale oil actually entails complete refining of the first tarry distillate, and later includes the manufacture of a long list of by-product commodities on the ground. The ideal plant will, therefore, comprise mining, refining and manufacturing, and present a very complicated problem of mining, mechanical and chemical engineering, as well as a business organization.

Field Development Under Way.

While most of the work in Kentucky oil shales has been of the laboratory experimental type to date, there are now certain evidences of expansion into field operations. Of the number of companies incorporated in this State for oil shale development, the Devon Oil Shale Corporation, organized in Cincinnati, Ohio, has been the first to get work started toward construction of its plant. Their location is close to Clay City, in Powell county, and considerable prospecting of quarry sites as well as grading has already been accomplished, as views in this report testify. Eight miles east of Mt. Sterling, in Montgomery county, but close to the Bath county line, the Central Oil Shale Corporation of Pittsburg, with a capitalization of $2,500,000, has selected a site for a plant, erected retaining walls, and made ready for construction. A plant site is reported to have been selected for Irvine in Estill county, and another for McKinney, in Lincoln county, while in the vicinity of Shepherdsville, or Lebanon Junction, in Bullitt county, it is reported that field developments will be started this year.

Tables covering distillation records, gravities, bitumen and silicate analyses, etc., are herewith appended.

TABLE NO. I.

OIL CONTENT OF THE DEVONIAN BLACK SHALE OF KENTUCKY

	County	Gal. Per Short Ton	Approx. Gas Vol. Per Short Ton
1.	Rockcastle	8.00	3,000
2.	Webster*	8.25	5,000
3.	Lewis	10.25	3,000
4.	Boyle	11.0	5,000
5.	Clark	11.0	5,000
6.	Bath	11.25	3,000
7.	Bullitt	11.5	8,000
8.	Rowan	12.5	8,000
9.	Jefferson	15.50	5,000
10.	Lincoln	15.5	8,000
11.	Marion	16.0	8,000
12.	Powell	16.75	8,000
13.	Elliott*	17.25	10,000
14.	Casey	18.0	8,000
15.	Madison	18.5	8,000
16.	Montgomery	19.0	8,000
17.	Nelson	19.0	8,000
18.	Garrard	21.0	10,000
19.	Fleming	21.5	10,000
20.	Estill	22.0	10,000
21.	Taylor	27.75	10,000

The samples are listed by counties in the order of increase of their oil content. While the gas content is variable it increases generally with the oil.

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*These samples from the Pottsville of Pennsylvanian of eastern and western Kentucky, not from the Devonian Black Shale.

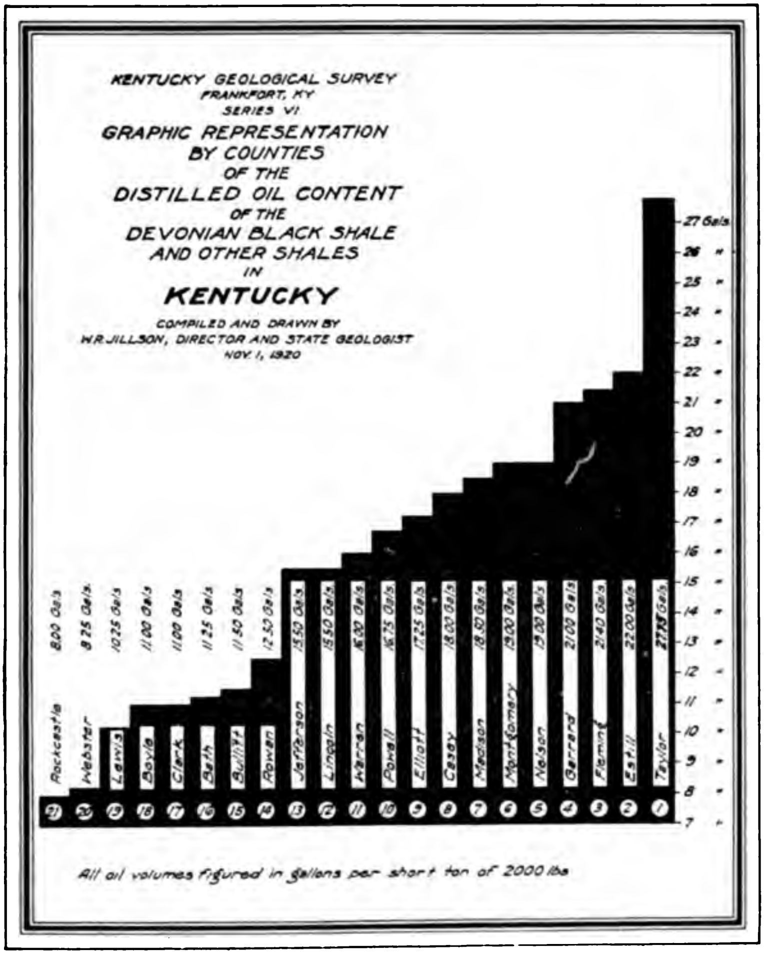
KENTUCKY GEOLOGICAL SURVEY
FRANKFORT, KY
SERIES VI
GRAPHIC REPRESENTATION
BY COUNTIES
OF THE
DISTILLED OIL CONTENT
OF THE
DEVONIAN BLACK SHALE
AND OTHER SHALES
IN
KENTUCKY
COMPILED AND DRAWN BY
W.R. JILLSON, DIRECTOR AND STATE GEOLOGIST
NOV. 1, 1920
Rockcastle 8.00 Gals
Webster 8.25 Gals
Lewis 10.25 Gals
Boyle 11.00 Gals
Clark 11.00 Gals
Bath 11.25 Gals
Bullitt 11.50 Gals
Rowan 12.50 Gals
Jefferson 15.50 Gals
Lincoln 15.50 Gals
Warren 16.00 Gals
Powell 16.75 Gals
Elliott 17.25 Gals
Casey 18.00 Gals
Madison 18.50 Gals
Montgomery 19.00 Gals
Nelson 19.00 Gals
Garrard 21.00 Gals
Fleming 21.40 Gals
Estill 22.00 Gals
Taylor 27.75 Gals
21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
27 Gals
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
All oil volumes figured in gallons per short ton of 2000 lbs

TABLE NO. II.

SPECIFIC GRAVITIES OF KENTUCKY OIL SHALES.

Samples of black shale in lumps taken from original samples as given in Table No. I. The sample numbers are identical though the numbers of the counties as given do not correspond due to differing arrangement.

	County	Specific Gravity	Weight of 1 Cu. Ft., Lbs.
1.	Bath	2.246	136.79
2.	Boyle	2.363	147.26
3.	Bullitt	2.367	147.51
4.	Casey	2.112	131.56
5.	Clark	2.260	140.77
6.	Elliott	1.968	122.59
7.	Estill	2.027	126.26
8.	Fleming	1.966	122.62
9.	Garrard	2.073	129.00
10.	Jefferson	2.198	136.78
11.	Lewis	2.320	144.51
12.	Lincoln	2.123	132.24
13.	Madison	2.047	127.50
14.	Marion	2.127	132.50
15.	Montgomery	2.078	129.44
16.	Nelson	2.126	132.43
17.	Powell	2.406	149.85
18.	Rowan	2.261	140.82
19.	Rockcastle	2.400	149.47
20.	Taylor	1.964	122.43
21.	Webster	2.197	136.92
	Average, 21 samples	2.173	129.37
	Maximum, Powell County	2,406	149.85
	Minimum, Elliott, Fleming	1.966	122.59

Alfred M. Peter.

November 30, 1920.

CLIFFS OF OIL SHALE.

This fine Devonian outcrop is in one of the several cuts of the Louisville and Nashville Railroad about a mile north of Shepardsville in Bullitt County, Ky.

A HILL OF KENTUCKY OIL SHALE.

The smooth, gently rounded slope is characteristic of the remnant knobs of black Chattanooga Shale (Devonian). This view is near Clay City in Powell County, but would answer well for the thousand other points on the ring of Devonian outcrop around the central Blue Grass region.

TABLE NO. III.

PROXIMATE ANALYSES OF KENTUCKY OIL SHALES

These analyses were made from the same samples as listed in the foregoing Tables I. and II. The samples were air dry and the volumes are figured in per cent.

COUNTY	Lewis	Rowan	Bath	Clark	Garrard	Marion	Fleming	Elliott	Boyle	Estill	Webster
Laboratory No. G	4008	4009	4010	4011	4012	4013	4014	4015	4016	4017	4018
Moisture	0.83	1.81	1.35	1.53	1.34	1.43	1.59	1.16	1.36	1.37	2.08
Vol. Comb. matter	10.84	12.49	10.79	10.26	15.03	13.47	16.72	15.65	10.31	15.14	11.91
Fixed carbon	4.61	8.77	5.88	5.99	9.80	8.29	9.63	14.64	4.43	10.06	6.98
Ash	83.72	76.93	81.98	82.22	73.83	76.81	72.06	68.55	83.90	73.43	79.03
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total combustible	15.45	21.26	16.67	16.25	24.83	21.76	26.35	30.29	14.74	25.20	18.89
Color of ash*	Russet vinaceous	Avellaneous	Light russet vinaceous	Vinaceous buff	Avellaneous	Vinaceous buff	Tilleul buff	Pale brownish drab	Avellaneous	Tilleul Buff	Pale Olive Buff
Sulfur	4.15	2.87	4.24	2.78	1.82	2.42	1.50	3.61	3.21	1.80	0.11
Phosphorus	.10	.96	.07	.12	.09	.07	.09	.32	.06	.32	.17
Nitrogen	.28	.39	.32	.26	.50	.43	.57	.59	.27	.53	.36
Per cent N in total combustible	1.80	1.83	1.92	1.60	2.01	1.98	2.16	1.95	1.83	2.10	1.91
Color of sample*	Deep grayish olive	Chaetura drab	Dark olive	Chaetura drab	Chaetura drab	Chaetura drab	Fuscous black	Sooty black	Chaetura black	Dark mouse gray	Blackish mouse gray
Carbonate	Small	Small	Small	Small	Small	Small	Small	Small	Small	Small some H_2S	Very small some H_2S

(Analyses by W. D. Iler)

*Ridgeway's Standards.

Alfred M. Peter.

TABLE NO. IV.

Nitrogen content of some samples of the Devonian black shale in Kentucky.

COUNTY	Jefferson	Montgomery	Rockcastle	Powell	Madison	Lincoln	Casey	Nelson	Bullitt
Lab. No. G	3974	3975	3976	4002	4003	4004	4005	4006	4007
Nitrogen	0.34	0.52	0.23	0.48	0.49	0.34	0.49	0.61	0.21
Per cent N. in total combustible	1.75	1.88	1.66	1.67	2.06	1.87	1.95	2.27	1.73

DISTILLATION RECORDS OF KENTUCKY OIL SHALES

Herewith are presented the detailed distillation and locational records of twenty-one specimens of Kentucky oil shales. The retorting was done by C. S. Crouse for the Kentucky Geological Survey.

OIL SHALE AT JUNCTION CITY.

Boyle County has some excellent Devonian Shale exposures, as this one on the Louisville and Nashville Railroad near the new Cumberland Grocery storehouse at Junction City demonstrates.

BATH COUNTY.

Distillation No. 1.

Location: About a half a mile from Salt Lick on the Caney Road. Sample taken on a hill at about twenty-five feet above a clay seam which lies near the bottom of the deposit.

Results: Oil, crude, 11.25 gal. per short ton shale. Gas, poor.

Dated, 10/13/20.

BOYLE COUNTY.

Distillation No. 2.

Location: In the western edge of Junction City near the building of the Kraemer Oil Co. Taken from a quarry on the north side of the road.

Results: Oil, crude, 11 gal. per short ton shale. Gas, fair.

Dated, 10/25/20.

BULLITT COUNTY.

Distillation No. 3.

Location: Just out of Shepherdsville on the Louisville-Shepherdsville road at the gap in the knobs where the road crosses the L. & N. R. R. on a high bridge. Sample taken from the railroad cut at the above location.

Results: Oil, crude, 5 gal. per short ton shale. Gas, good.

Dated, 10/9/20.

A BULLITT COUNTY SHALE OUTCROP.

There is a very thick and workable deposit of black Chattanooga Shale just north of Shepardsville, as this view on the Louisville and Nashville Railroad shows.

CASEY COUNTY.

Distillation No. 4.

Location: About a quarter mile west of the gap in the knobs on the Hustonville-Bradfordsville pike. Sample taken from a small road quarry to the right of the road on Mrs. Power's farm.

Results: Oil, crude, 18 gal. per short ton shale. Gas, good.
Dated, 10/11/20.

CLARK COUNTY.

Distillation No. 5.

Location: About a half a mile east of Indian Fields on the Winchester-Clay City road. Sample taken from an old road quarry situated just over the crest of a hill from a school house.

Results: Oil, crude, 11 gal. per short ton shale. Gas, fair.
Dated, 10/21/20.

ELLIOTT COUNTY.

Distillation No. 6.

Location: From the first 100 feet of the Basal-Pottsville exposed in the branch at the head of Corn Hollow on the Charles LeMaster farm on the head waters of Big Sinking Creek.

Results: Oil, crude, 17.25 gal. per short ton shale. Gas, excellent.

Dated, 10/30/20.

This bituminous shale was collected from the Lower Pottsville formation on the head waters of Big Sinking Creek in Elliott County, Ky., by W. R. Jillson, Sept., 1920. It is not the Black or Chattanooga (Devonian) Shale.

ESTILL COUNTY.

Distillation No. 7.

Location: About two miles from Irvine on the opposite side of the Kentucky River as the road goes to Richmond.

Results: Oil, crude, 22 gal. per short ton shale. Gas, excellent.
Dated, 9/—/1920.

FLEMING COUNTY.

Distillation No. 8.

Location: Taken from near the top of the first mountain east of Ringo's Mill. Sample came from near the top of the deposit.

Results: Oil, crude, 21.5 gal. per short ton shale. Gas, excellent.
Dated, 10/29/20.

GARRARD COUNTY.

Distillation No. 9.

Location: From the bottom of Copper Creek which is the Rockcastle-Garrard County line. Sample from the spot where Copper Creek road crosses the creek.

Results: Oil, crude, 21 gal. per short ton shale. Gas, excellent.

Dated, 10/23/20.

JEFFERSON COUNTY.

Distillation No. 10.

Location: About one mile south of Twin Oaks Park on the Ash Bottom road. Sample taken from freshly blasted material from a well being dug on the L. & N. R. R. property at about 100 ft. to the right of the road.

Results: Oil, crude, 15.5 gal. per short ton shale. Gas, fair.

Dated, 9/28/20.

LEWIS COUNTY.

Distillation No. 11.

Location: About a mile and a half from Vanceburg on the Maysville road. Sample taken from cut along road.

Results: Oil, crude, 10.25 gal. per short ton shale. Gas, good for a short time.

Dated, 10/16/20.

THE CONLEY-CRABTREE OUTCROP.

An excellent natural exposure of the black Chattanooga Shale occurs on this farm in a bed of the Red River about two miles east of Clay City and one-half mile from the Louisville and Nashville Railroad. The shale deposit here is about seventy-five feet thick.

LINCOLN COUNTY.

Distillation No. 12.

Location: About one mile from Milldgeville on the Black pike. Sample taken from the ditch alongside the road.

Results: Oil, crude, 15.5 gal. per short ton shale. Gas, good.

Dated, 10/8/20.

MADISON COUNTY.

Distillation No. 13.

Location: In Berea. Sample taken from blasted material from the cellar of the house of the president of Berea College, Dr. Frost.

Results: Oil, crude, 18.5 gal. per short ton shale. Gas, good.

Dated, 9/30/20.

MARION COUNTY.

Distillation No. 14.

Location: About a half mile east of Lebanon on the Lebanon-Danville pike. Sample taken from a quarry in Ryder's cemtery.

Results: Oil, crude, 16 gal. per short ton shale. Gas, good.

Dated, 10/17/20.

DETAIL OF KENTUCKY OIL SHALE.

This exposure of black Chattanooga Shale is found in one of the several quarries of the Devon Shale Products Co., near Clay City. The view is characteristic of the fresh shale surface.

MONTGOMERY COUNTY.

Distillation No. 15.

Location: About eight miles east of Mt. Sterling on the Old Town road. Sample taken from ditch alongside road near the farm of Mr. Cravens. Sample from near the bottom of the deposit.

Results: Oil, crude, 19 gal. per short ton shale. Gas, good.

Dated, 9/27/20.

NELSON COUNTY.

Distillation No. 16.

Location: About one mile from Boston on the Boston-Bardstown road. Sample taken from a quarry on top of a hill.

Results: Oil, crude, 19 gal. per short ton shale. Gas, good.

Dated, 10/7/20.

POWELL COUNTY.

Distillation No. 17.

Location: About one mile east of Clay City. Sample taken from the property of the Devon Oil Shale Products Company.

Results: Oil, crude, 16.75 gal. per ton shale. Gas, good.

Dated, 10/12/20.

ROCKCASTLE COUNTY.

Distillation No. 18.

Location: On Boone Highway at Gum Sulphur. Sample taken from cut along road on the south side of Gum Sulphur Creek.

Results: Oil, crude, 8 gal. per short ton shale. Gas, poor.

Dated, 9/29/20.

ROWAN COUNTY.

Distillation No. 19.

Location: At the quarry of the Rowan County Freestone Company. Sample taken from just below the soapstone.

Results: Oil, crude, 12.5 gal. per short ton shale. Gas, good.

Dated, 10/22/20.

TAYLOR COUNTY.

Distillation No. 20.

Location: Outcrop in Robinson Creek near Mansville, Taylor County.

Results: Oil, crude, 27.75 gal. per short ton shale. Gas, excellent.

Dated, 10/30/20.

WEBSTER COUNTY.

Distillation No. 21.

Location: From the farm of Harden Asher near Tilden.

Results: Oil, crude, 8.25 gal. per short ton shale. Gas, fair.

Dated, 11/1/20.

This bituminous shale was collected from the Pottsville formation in Webster County, Ky., by W. R. Jillson, Sept., 1920. It is not the Black or Chattanooga (Devonian) Shale.

SEPARATE ANALYSES OF KENTUCKY OIL SHALES.

ESTILL COUNTY.

Analysis No. 1.

Laboratory No. 56357.—Devonian black shale from Estill County, Ky., brought March 21, 1919, by H. D. Kremer.* Sample, a ½ lb. of clean shale without appearance of weathering but containing some pyrite.

Analysis of the air-dried sample.	Pen cent.
Moisture at 105° C.	0.5
Volatile combustible matter	26.6
Fixed carbon	4.4
Salmon-colored ash	68.5
	100.0
Total combustible matter	31.0
Sulfur	4.86
Nitrogen	0.67
Per cent of N in the total combustible matter	2.16

(Analysis by A. M. Peter.)
March 21, 1919.

Analysis No. 2.

Laboratory No. 56358.—Crude oil distilled by H. D. Kremer from the Estill County black shale. He reports the yield at the rate of about 23 gallons per ton by laboratory test. Sample, a thin, brown oil having the characteristic shale-oil odor.

Specific gravity, 0.900 or 25.6° B.

	Per cent by volume
Distillate below 150° C. (302° F.)	
Gasoline fraction	16.3
Distillate from 150° to 300° C. (302-572° F.)	
Kerosene fraction	39.3
Brown liquid residue and loss, by difference	44.4
	100.0

(Analysis by A. M. Peter.)
March 21, 1919.

*These results were privately published by Mr. Kremer in a pamphlet, in 1919.

A BOYLE COUNTY SHALE OUTCROP.

This view is on the Jack Adams farm, three miles west of Junction City. This deposit of Devonian black shale is located on the Danville-Lebanon pike and the Louisville and Nashville Railroad.

Experiment II, using 250 grams of shale in the same apparatus and heating faster, gave:

	Per cent by weight
Tar	7.29
Water	2.00
Residue	85.80
Gas and loss	4.91
Total	100.00

The residue was found to contain:

	Per cent.
Volatile combustible matter	13.13
Fixed carbon	3.90
Ash	68.77
	85.80

Calculated as per cent of the residue, this gives:

	Per cent.
Volatile combustible matter	15.30
Fixed carbon	4.55
Ash	80.15
	100.00

Experiment III, 250 gr. distilled in the same apparatus, raising the heat as rapidly as possible, gave:

	Per cent by weight
Tar	8.15
Water	2.00
Residue	85.60
Gas and loss	4.25
	100.00

A POWELL COUNTY SHALE EXPOSURE.
The view is along the Louisville and Nashville Railroad cut on the John Everman farm about three miles west of Clay City.

Inasmuch as the three experiments were made upon different portions of the same powdered sample, in the same apparatus, the only difference being in the rate of heating, it is evident that rapid heating gives a larger yield of tar than slow heating. Calculating on the basis of a ton these yields would correspond to 132.2 lbs., 145.8 lbs. and 163 lbs. of tar per ton of shale, or 14.9 gallons, 16.4 gallons and 18.3 gallons per ton, respectively, assuming the specific gravity of the tar to be 0.9 (25.6° B.).

The tar obtained in these experiments was not fractionated.

(Analyses and tests by A. M. Peter.)

March 21, 1919.

Analysis No. 3.

Laboratory No. 56312.—Devonian black shale from Estill County brought February 13, 1919, by Prof. W. R. Jillson. Sample, a 3½ lb.

piece of hard shale, showing some weathered surfaces and a plate of pyrite on one side. Ground half the lump for analysis, after breaking off the pyrite and weathered parts.

Analysis of the air-dried sample.

	Per cent.
Moisture at 105° C.	0.69
Volatile combustible matter	26.56
Fixed carbon	2.77
Yellowish-brown ash	69.98
Total	100.00
Total combustible matter	29.33
Sulfur	1.87
Nitrogen	0.57
Per cent nitrogen in the total combustible matter	1.94

Qualitative tests show that the shale contains some calcium carbonate, iron carbonate and traces of phosphate and zinc sulfid.

Three experiments were made by distilling the coarsely powdered shale in a small iron retort heated by a gas burner.

Experiment 1, using 200 grams of shale and heating slowly, gave:

	Per cent by weight
Thick reddish-brown tar	6.61
Water	1.75
Black, pulverulent residue	88.00
Gas and loss, by difference	3.64
	100.00

The reddish-brown tar becomes dark brown on exposure to the air. Its odor is like that of bone oil and it gives a good test for pyrrol (Analysis by A. M. Peter.)
November 18, 1920.

HANCOCK COUNTY.

Analysis No. 4.

Laboratory No. 17873.—Black shale sent in October, 1907, by H. Y. Smith, Lewisport, Hancock County, Ky., to determine if it has any value as a fertilizer.

Analysis by digestion in hydrochloric acid (1.115 sp. gr.), gave:

	Per cent.
Calcium oxid, CaO (lime)	3.93
Phosphorus, P.	0.16
Potassium oxid, K_2O (potash)	0.43

(Aanlysis by S. D. Averitt.)
November 19, 1920.

CASEY COUNTY.

Analysis No. 5.

Laboratory No. 25767.—Black shale sent in January, 1910, by Jesse Lawhorn, Yosemite, Casey County, Ky., from his farm 4 miles south of that place.

Analysis of the air-dried sample.	Per cent.
Volatile combustible matter and moisture	13.10
Fixed carbon	10.77
Dark gray ash	76.13
	100.00
Total combustible matter	23.87
Phosphorus	0.13

(Analysis by A. M. Peter.)
November 19, 1920.

LAUREL COUNTY.

Analysis No. 6.

Laboratory No. 56319.—Cannel shale, Lee formation, Laurel County, Ky., collected by Prof. A. M. Miller. Sample brought by Prof. Miller, February 19, 1919.

Analysis of the air-dried sample.	Per cent.
Moisture at 105° C	1.24
Volatile combustible matter	34.88
Fixed carbon	44.44
Purple ash	19.44
	100.00
Total combustible matter	79.32

A distillation of 175 grams in the same retort used for the Devonian shale gave:

	Per cent by weight
Tar	14.4
Water	5.5
Coke (loosely caked)	70.8
Gas and loss, by difference	9.3
	100.0

The tar had a distinct odor of phenol (carbolic acid). The yield of tar is at the rate of 288 lbs. to the ton of shale, or 32.4 gallons, assuming the specific gravity to be 0.9.
(Analysis by A. M. Peter.)
November 19, 1920.

MORGAN COUNTY.

Analysis No. 7.

Laboratory No. G-4039.—Black shale, labeled "Cannel slate (oil shale) from two-foot outcrop in creek on the farm of Dr. J. Gullett, one-half mile above Wrigley, Morgan County, Kentucky. Collected by W. R. Jillson, Dec. 13, 1920." Sample, a 4 lb. piece of slate-black shale, weathered on two edges, with flat conchoidal fracture and containing some pyrite; considerable effloresced ferrous sulfate was visible on the more weathered surface. Broke off the weathered parts.

Analysis of the air-dried sample.	Per cent.
Moisture	1.29
Volatile combustible matter	37.90
Fixed carbon	30.40
Ash	30.41
Total	100.00
Total combustible	68.30
Sulfur	1.18
Phosphorus	0.10
Nitrogen	0.75
Per cent nitrogen in total combustible	1.10
Color of sample, slate-black.*	
Carbonate	present
Specific gravity	1.957
Weight per cubic foot	121.96

(Analysis by W. D. Iler.)
December 28, 1920.

TAYLOR COUNTY.

Analysis No. 8.

Laboratory No. G-4021.—Black shale, received November 24, 1920, from Prof. W. R. Jillson, labeled "near Mansville, Taylor County, 11-19-20." Sample, about ½ lb. of "fuscous black" colored shale, from ⅛" to dust.

*Ridgeway's Standards.

ANALYSIS.

Analysis of the air-dried sample.	Per cent.
Moisture	1.10
Volatile combustible matter	18.38
Fixed carbon	13.12
Ash (flesh color)	67.40
Total	100.00
Total combustible	31.50
Sulfur	1.44
Phosphorus	0.22
Nitrogen	0.63
Per cent nitrogen in total combustible	2.06
Color of sample, "fuscous black."*	
Carbonate, a trace.	
Specific gravity, 1.964.	
Weight per cubic foot, 122.43 lbs.	

(Analysis by S. D. Averitt.)
December 22, 1920.

ANALYSIS OF SUNBURY OIL SHALE.

In 1866, in the months of February, March, April and May, Dr. Robert Peter did considerable work on two lots of crude oil obtained by distillation from Devonian black shale at the "Lingula Shale Oil Works," Vanceburg, Lewis Co., Ky., sent by William F. Patterson.

The material is described as a "dark, nearly black, rather thin, tar-like oil" and the yield is noted as being "about 20 gallons to 2,000 lbs." of shale.

One of the lots examined is described as having been produced by "the destructive distillation of Devonian black slate" and the other as having been produced "by the use of superheated steam." The specific gravity of the first is given as 0.935 (19.7° B.) and of the second as 0.933 (20.1° B.). The second lot is described as being a little lighter colored than the first; otherwise they seem to have been practically identical. No statement is made as to the yield by steam distilation.

The work seems to have been directed mainly toward purifying the distillates for the production of burning oil, lubricating oil and the more volatile products (gasoline). The result of a fractional distillation is recorded as follows:

*Ridgeway's Standards.

	Per cent.		
Distilled from ....240 to 245° F.........	0.3		
Distilled from ....245 to 300° F.........	3.3		
Distilled from ....300 to 400° F.........	11.8	Specific gravity........	0.806
Distilled from ....400 to 480° F.........	12.0	Specific gravity........	0.848
Distilled from ....480 to 560° F.........	14.7	Specific gravity........	0.891
Distilled from ....560 to 600° F.........	28.2	Specific gravity........	0.954
Pitchy residue and loss	29.7		

This might be summarized as:

	Per cent.
Gasoline fraction	3.6
Burning oil fraction	38.5
Paraffin oil fraction	28.2
Pitchy residue and loss	29.7

Dr. Robt. Peter seems not to have identified any chemical products except pyrrol and phenol (carbolic acid) both of which were detected. November 19, 1920.

With a view to determining whether the silica contained in the residues from distillation of the shales would render them immediately suitable for use in the manufacture of Portland cement a number of silicate analyses have been made on the various shales. In the following tables the first gives results calculated from the original sample. In the other second the percentages have been secured by computation of the residue or ash remaining after the burn. The figures show that the residue is not suitable immediately for the making of Portland cement. It is possible, however, that this residue might be used in combination with a more silicious material so as to balance the ratio of the alumnia and iron oxide to the silica properly. The ratio as it stands in the residues remaining after the burning is too low. Another way to state it is to say that the silica is deficient as compared to the alumina and iron. The tables follow.

TABLE NO. V.

SILICATE ANALYSES OF BLACK SHALES.

County Laboratory Number	Lincoln G-4004	Bullitt G-4007	Lewis G-4008	Elliott G-4015	Estill G-4017	Webster G-4018
Moisture at 104° C	1.32	0.76	0.83	1.16	1.37	2.08
Loss on burning	19.72	12.92	16.28	31.45	26.57	20.97
Silica, SiO_2	43.70	51.10	48.50	42.26	38.30	38.18
Alumina, Al_2O_3	22.29	19.76	19.27	13.63	18.12	26.80
Ferric oxid, Fe_2O_3*	7.58	8.38	9.18	8.14	6.71	6.63
Calcium oxid, CaO	0.67	1.29	1.63	0.80	1.37	0.81
Magnesium oxid, MgO	1.39	1.18	0.88	0.53	1.15	1.34
Potassium oxid, K_2O	3.21	3.11	1.74	0.85	2.41	2.43
Sodium oxid, Na_2O	0.31	0.38	0.09	0.04	0.19	0.37
Titanium dioxid, TiO_2	0.63	0.43	0.45	0.31	0.63	0.63
Phosphorus pentoxid, P_2O_5	0.20	0.11	0.24	0.74	0.74	0.38
Total	101.02	99.42	99.09	99.91	97.56	100.62

TABLE NO. VI.

SILICATE ANALYSES, CALCULATED AS PER CENT OF THE BURNED SHALE.

County Laboratory Number	Lincoln G-4004	Bullitt G-4007	Lewis G-4008	Elliott G-4015	Estill G-4017	Webster G-4018
Silica, SiO_2	54.64	59.56	59.16	62.80	55.02	49.23
Alumina, Al_2O_3	27.86	23.07	23.51	20.25	26.03	34.55
Ferric oxid, Fe_2O_3	9.48	9.78	11.20	12.09	9.64	8.54
Calcium oxid, CaO	0.84	1.51	1.99	1.18	1.97	1.04
Magnesium oxid, MgO	1.74	1.38	1.07	.78	1.65	1.73
Potassium oxid, K_2O	4.01	3.63	2.12	1.26	3.46	3.13
Sodium oxid, Na_2O	0.39	0.44	.11	.06	.27	.48
Titanium dioxid, TiO_2	0.79	.50	.55	.48	.90	.81
Phosphorus pentoxid, P_2O_5	0.25	.13	.29	1.10	1.06	.49
Total	100.00	100.00	100.00	100.00	100.00	100.00

*The iron is in the ferrous condition in the shale.

TABLE NO. VII.

HYPOTHETICAL COMBINATIONS IN THE SAMPLES OF BLACK SHALE.

Assuming that the sulfur is from pyrite, the iron from this and ferrous carbonate, the alkalies and alumina from orthoclase and kaolinite, the phosphorus from tricalcium phosphate and the lime and magnesia from the carbonates.

County Laboratory Number	Lincoln G-4004	Bullitt G-4007	Lewis G-4008	Elliott G-4015	Estill G-4017	Webster G-4018
Water at 105° C.	1.23	0.76	0.83	1.16	1.37	2.08
Kaolinite, $Al_2Si_2O_5, 2H_2O$	48.87	39.91	46.16	32.01	38.49	59.64
Orthoclase, $(KNa)_2\ Al_2Si_6O_{16}$	21.65	21.65	11.08	5.38	15.90	16.45
Pyrite, FeS_2	2.68	4.25	7.76	6.75	3.37	0.21
Ferrous carbonate, $FeCO_3$	8.42	8.05	5.82	5.28	6.49	9.42
Calcium carbonate, $CaCO_3$	.91	2.14	2.57	0.38	1.41	0.91
Magnesium carbonate, $MgCO_3$	2.91	2.47	1.84	1.11	2.40	2.80
Tricalcium phosphate, $Ca_3P_2O_8$	0.45	0.25	0.52	1.62	1.61	0.84
Free silica, SiO_2	6.79	18.34	19.78	23.85	10.00	....
Titanium dioxid, TiO_2	0.63	0.43	0.45	0.31	0.63	0.63
Combustible matter, by difference	5.46	1.75	3.19	22.15	18.33	7.02
Total	100.00	100.00	100.00	100.00	100.00	100.00

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Although still an infant in its American development, the oil shale industry has forged ahead with marvelous strides, especially in the west in Colorado and Utah and adjoining states. In keeping with the field and laboratory advance, there has been a corresponding growth in the literature pertaining to oil shales, their location, geology, methods of retorting and refining. In a necessarily brief treatise such as is here presented on Kentucky, it is manifestly impossible to go into all the interesting and important details of the oil shale industry now set forth in the published literature. This information must remain for a later, more comprehensive, and separate treatment.

Believing, however, that there are many now interested in the advancement of the oil shale industry in Kentucky, to whom a good bibliography on the subject would be of much value,

the following list of titles, partially annotated, is herewith presented. Not claiming completeness as a virtue, it contains much, however, that should be of interest to prospective operators of Kentucky oil shale. The names of all publishers are given, so that those desiring may secure the information directly by correspondence. The publications here listed are, with a very few exceptions, either freely distributed or procurable for a small charge.

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II.

KENTUCKY ROCK ASPHALT—THE IDEAL ROAD SURFACE.

INTRODUCTION.

The dawn of a new day for better roads in Kentucky is at hand. With the close of the World War and the return of national thought to the upbuilding of our country, there has come as a fundamentally important part of the program of reconstruction, the studied popular desire to do now a great work in national road building. This movement has developed its greatest momentum within the last year, though it really found its inception in the minds of a few progressive and far seeing individuals and statesmen a full decade ago.

Good roads were to be found at various and disconnected places throughout the northern and north-eastern states and to a very limited extent in Kentucky previous to 1900, but they had been established, for the most part, as a local convenience, and expressed little more than the progressiveness and civic pride of the immediate section in which they were located. The national conscience, so far as an intersecting system of good and passable roads was concerned, had not yet awakened. What a great contrast to today, when state after state in this great union takes up this difficult problem of interstate and intercounty seat roads as one of the most fundamental problems for its present and future development. Meetings of farmers, bankers, town and city councils, the voting of bond issues by municipalities, counties and states, running from a few hundred thousand dollars to ten and twenty millions of dollars are all straws of greater or lesser value before the wind of this forward-looking movement for good and better roads.

As would, of course, be natural, the impetus given by thousands of good road campaigns, local, county and state-wide, has resulted in a careful investigation of all old methods of durable road building. At the same time much thought and money have been expended to bring out and present before an interested

FACE OF NOLIN RIVER QUARRY.

Close-up view of quarry now being operated by the Kentucky Rock Asphalt Co. on the Nolin River in Edmonson County, Ky.

public new methods and new materials for the construction of town, city and country roads. So it has come to pass that the engineering technique of road building as well as the quality, durability, cheapness, accessibility, and what not other virtues of every kind of scientifically constructed durable road, has been on trial, as it were, before a very critical audience. And this audience has been more than ordinarily critical, due to the fact that the decision with respect to the choice of the kind of road to be built has had, and is to have, a greater and more direct bearing on the pocketbook of each and every individual taxpayer.

During the growth of this nation-wide good roads movement, Kentucky, somewhat more fortunate than her sister states, has developed from her own resources a new, practical and economical kind of road, which is surfaced with asphaltic rock,

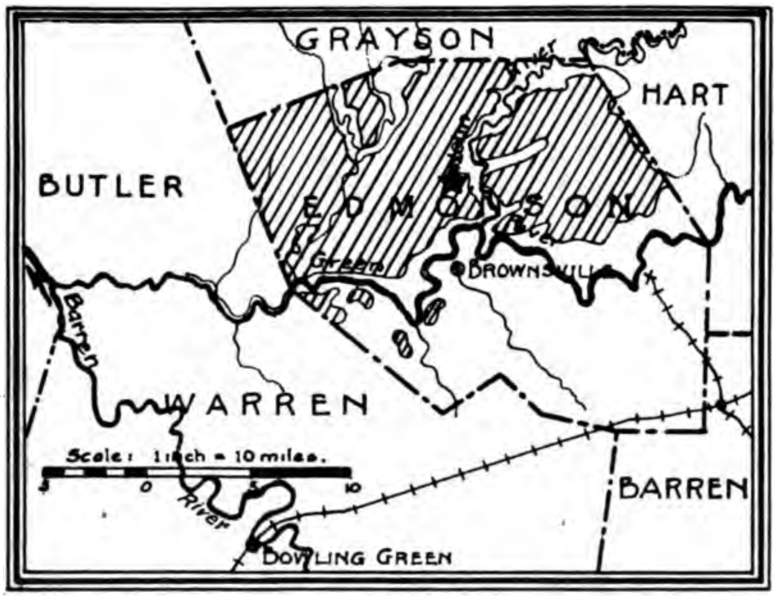
A WELL KNOWN ASPHALT ROAD.

The 18th Street Road (Dixie Highway) leading out of Louisville to Camp Knox. Here may be found 7½ miles of Kentucky Rock Asphalt laid on a macadam base. This road was constructed in 1915 and 1916 under State aid. During the period of the war it carried an average of 4,200 vehicles per day, a large percentage of which was heavy army trucks. Topography of the Ohio River bottom.

a home product. Asphalt rock or "black rock," as it is more commonly called by the natives in those sections where it naturally outcrops, is found in very fine quality and large quantities in the southern-central and the north-eastern parts of this Commonwealth. The use of Kentucky asphalt rock as an ideal road material has gone forward in the last few years so quietly and satisfactorily that few people will believe that it is today being used as a pavement and rendering excellent service throughout many states, and in this state, in the cities, and country vicinities of Louisville, Lexington, Hopkinsville, Louisa, Lawrenceburg, Bardstown, Elizabethtown, Covington, Middlesboro, Pineville, Harlan, Corbin, Barbourville, Bowling Green, Versailles, Frankfort and Winchester.

Location and Geology.

Kentucky asphalt rock, from which these roads have been constructed, and out of which countless new ones are now being



WESTERN KENTUCKY ASPHALT FIELD.

Sketch map showing distribution of the Pottsville in Edmonson County. The largest commercial asphalt rock operations are located near the star on the Nolin River. Asphalt is found in all of the adjoining counties except Barren.

prepared, is found in its natural position as an asphaltic impregnated sand from five to forty feet in thickness on the eastern and south-eastern border of the western coal field in Hart, Grayson, Edmonson, Warren, Butler, Logan, Breckinridge, and other adjoining counties. Asphaltic sandstone has also been found in outcrop and examined by the writer on Soldier and Mocabee creeks near Soldier Station, on the Chesapeake and Ohio railroad in Carter county. It may also exist a short distance to the west across the Rowan county line, which is close to Soldier.

The Soldier area is a small one, being estimated at less than three miles in diameter. Close to Soldier five to ten foot out-

THE DANNER ASPHALTIC SANDSTONES.
At this outcrop the bedded asphaltic sandstones have been prospected and the fragmental debris has been thrown up so as to hide the lower exposures.

crops are found above drainage on the following farms: Mrs. J. P. Danner, J. D. Patton, L. S. Vincent, J. F. Gilbert, W. C. Underwood and S. M. Bradley, and others. In the section the bituminous sandstone is underlain by five to six feet of fire clay, which is widely operated, and overlain by fifteen to twenty feet of exposed soft, coarse grained sandstone.

On the J. D. Patton farm a fire clay entry 300 feet back from the main opening developed a large seepage of tarry or asphaltic oil from this sandstone. The leakage was caught by the use of powder kegs to the extent of several barrels, and was lo-

cally used as a lubricant, and for other domestic purposes. The finding of it is in conformity with the results of the several analyses of the Soldier asphaltic sands, and further affirms the great irregularity of the asphaltic impregnation. On the Mrs. J. P. Danner farm a rather considerable quarry was developed by Mr. J. G. Ryan, of Pittsburg, Pa., in 1917. It was never comercialized. Irregularity of asphaltic impregnation is here a notable characteristic. The quarry has been abandoned.

Asphalt impregnated sandstones in the cliffs of Big Paint creek gorge near Low Gap branch and at other points in the main gorge and its tributaries in Johnson and the adjacent por-

AN ENTRANCE TO PAINT CREEK GORGE.
The view is in the upper part of the creek and shows the walls somewhat lower due to the dip to the west off from the top of the main uplift. Asphalt impregnated lenticles are of frequent occurrence in this portion of Johnson County.

tions of Morgan and Magoffin counties have been studied by the writer. These bituminous sandstones are, however, of scientific interest only, since they are not thick enough nor so situated from a mining engineering standpoint as to be commercial. Like the north-eastern and western-central Kentucky outcrops,

they are interesting to the student of olenus accumulations in true silica sands, having been without doubt during the geologic past a productive oil sand.

Stratigraphically the asphalt rock of western-central Kentucky is found in what is known as the Chester sandstones of the Mississippian system, and again in the overlying Pottsville Conglomerate sandstones of the Pennsylvanian system. The north-eastern Kentucky asphaltic sands in Carter and Rowan counties are undoubtedly Pottsville. The Johnson and adjacent Morgan and Magoffin county asphaltic sands are Pottsville basal conglomerate sediments of the Pennsylvanian system.

From a commercial standpoint the best and most workable deposits of asphalt rock are those of the Pottsville group of western-central Kentucky. The largest and best deposits of this group are now being worked by the Kentucky Rock Asphalt Co. This corporation, the largest of its kind in the State, operates a plant having a daily capacity of from five hundred to

PANORAMA OF THE NOLIN RIVER OPERATION.

The view shows the plant of the Kentucky Rock Asphalt Co., in incline railroad leading to crushers and pulverizing mill. The loading dock at the Nolin River may be seen at the extreme lower right-hand corner. Topography of the Lower Pottsville.

a thousand tons, on the Nolin river at Kyrock. This company and operation, which is the legal successor of the American Standard Asphalt Co., formerly of Russellville, Ky., is located in Edmonson county, about six miles from the confluence of the Nolin and the Green rivers. The rock occurs as a remnant, asphalt impregnated, true siliceaus sandstone close to the top of the ridges. It is in reality all that is left of an oil sand whose lighter and more volatile constituents have long since disappeared into the air through countless exposures. The existence of this and other widespread deposits of asphalt has long been known in this State. They may be found mentioned in some of the very early reports of the Kentucky Geological Survey. Their commercial importance, however, was not considered until a few years ago, and it now appears that Kentucky in this, as in many other cases, overlooked for many years one of her most valuable and important mineral resources.

STRIPPING THE OVERBURDEN OF SOIL.

View of the Kentucky Rock Asphalt Co.'s quarry at Kyrock, Edmonson County. Quarrymen are removing over-burden with type "a" Universal Stripping Nozzle.

Methods of Mining and Preparation.

The mining and preparation of Kentucky Rock Asphalt at Kyrock for use as a road surfacing material is a simple process, though one not easily effected. Its natural position as a remnant strata, close to the top of ridges, allows of two time-honored methods, which are worked in conjunction. One of these is the steam shovel, such as is used in the great iron ore pits of the north and the south; and the other is the hydraulic pressure line, such as is used in the placer gold mines of California and Alaska. Where the cover of rock and soil is not more than six feet in thickness, the water pump with a pressure of one hundred and sixty pounds to the square inch, removes everything before it, including small vegetation. When the blanket of soil and bed rock is thicker, it is stripped by use of the steam shovel.

In either case, as soon as the asphaltic sandstone is exposed, it is removed by ordinary quarry methods, and conveyed by

GENERAL VIEW EDMONSON COUNTY QUARRY.

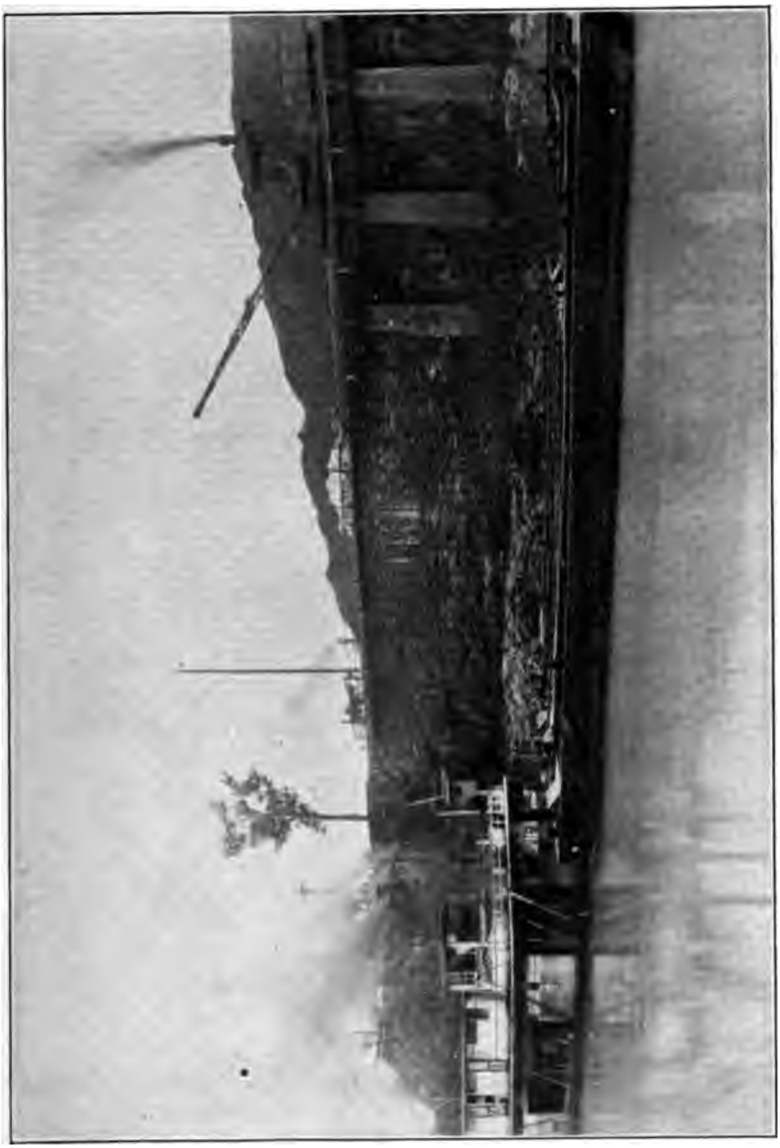
The method of handling the commercial rock asphalt and the low grade over-burden is well shown by the double tramway. The high position of these lower Nolin deposits on the hills allows of an almost ideal mining operation.

means of a little tramway and then by gravity to the crusher. The asphalt rock enters the crusher plant in cubes of from five to ten inches. After crushing to the size of an egg it is forwarded by a conveyor to the pulverizer, from which it comes immediately and continually like corn meal from the mill. At

INSIDE THE NOLIN RIVER ASPHALT MILL.

Pulverizers, Kentucky Rock Asphalt Co.'s plant. Each machine has capacity of 350 tons per ten hours.

this point samples are taken from each ton for analysis. The pulverizer feeds into one ton bucket conveyors which lead from the mill to the barges at the wharf on the Nolin river. The buckets are dumped automatically as they pass over the barges and then return to the mill. This mill is now producing between 500 and 600 tons of asphalt rock per day and will soon have a capacity, due to the installation of new machinery, of about 1,000 tons. As fast as they are loaded the barges are conveyed by tug down the Nolin and Green rivers, through the locks,



FROM RIVER BARGE TO RAILROAD.

The Barren River terminal, Bowling Green, Ky. 20,000 tons of Kentucky Rock Asphalt stored ready for immediate shipment.

and up the Big Barren river to Bowling Green, where two huge hungry locomotive cranes relieve them of their load. The rock asphalt is here either put in storage, or loaded directly into cars on the railroad, for the road building public.

Rock Asphalt as a Road Surface.

Of all the road material used in the United States, asphalt is by far the most popular. The reasons for this popularity are many, but relative cheapness, noiselessness, appearance and ease of construction and repair are probably the outstanding virtues. The widespread use of imported asphalt as a road surfacing material has, however, been considerably restricted by its relatively high cost, which term includes original cost plus maintenance. Ordinary imported asphalt requires mixing with sand and other material in especially constructed machines, with a certain amount of heating, and it must be hot while being transferred The required subsurface is also very costly, and added to this work of repairing must always be carried out along lines parallel to the original expensive construction.

The "Kentucky Rock Asphalt" pavement, using the commercialized or trade name, eliminates all of these above enumerated drawbacks associated with the construction of the ordinary asphalt road. And in addition to a saving of time and trouble, the most important consideration is that a road built of Kentucky Rock Asphalt costs less than any of the other high class pavements.

Kentucky Rock Asphalt as a commercial product comes from the quarry thoroughly mixed in correct proportions. It is laid without heating in ordinary temperatures, by common labor, and no particular machinery is required except that used in making the ordinary limestone road. Repairs, when necessary, are just as simple, and inexpensive. Kentucky Rock Asphalt is laid on an ordinary base of hard sandstone, slag, limestone, granite, concrete or brick, and is leveled with rakes by common labor. An ordinary ten ton roller used in preparing the broken stone base may also be used for the surface. There are no extra materials to be added to the top of Kentucky Rock Asphalt, and as soon as it is rolled under ordinary temperatures it is ready for use.

Should a depression occur in the foundation, or should repairs have to be made following excavation of one kind or another, it is only necessary to restore the foundation to its proper height, cut a rectangler hole in the surface, and fill in with Kentucky Rock Asphalt. This should then be rolled, but if the opening has been very small, the traffic may be relied upon to compact it sufficiently.

THE SOLDIER ASPHALT-ROCK QUARRY.
This vein on the Widow Danner farm near Soldier shows the quarried as well as the natural outcrop. There is considerable overburden on the Danner and adjoining properties.

THE DURABLE ROADWAY.

The reason for the durability of Kentucky Rock Asphalt roads is found in the nature and constituency of the material itself. The base is a true siliceous sand, which is very hard and very irregular. Each sand grain is coated by a film of freshly exposed bitumen (asphalt). This is the cementing, holding and water-proofing material. The amount of asphalt found in the Edmonson county deposits of Pennsylvanian age varies but slightly from one commercial sample to another, but is generally from about seven to eight per cent as is shown by the two analyses submitted herewith by Dr. A. M. Peter, State Chemist. The first of these is of the natural rock, and the second is of the pulverized material ready for use. It will be noticed that the

amount of sand is practically the same and that there is only a difference of fourteen one-hundredths of one per cent in the amount of bituminous matter or asphalt. This is very slight and may be explained by the larger amount of moisture in the pulverized as compared with the crude, unpulverized rock.

EDMONSON COUNTY.

Two samples of bituminous sandstone received February 13, 1920, from W. R. Jillson, State Gologist, as follows:

Analysis No. 1.

Laboratory No. G-3889, labeled "Average crude sample of Kentucky asphalt rock (Pottsville) collected by W. R. Jillson, January, 1920, from the quarries of the Kentucky Rock Asphalt Co., on the Nolin River, six miles above mouth of Edmonson County, Ky." Sample consists of a 5 oz. piece of bituminous sandstone containing a few quartz pebbles.

Analysis No. 2.

Laboratory No. G-3890, labeled "Pulverized Kentucky asphalt rock (Pottsville) collected by W. R. Jillson, January, 1920, from the mill of the Kentucky Rock Asphalt Company on the Nolin River, six miles above mouth, in Edmonson County, Ky." The sample consisting of about a pound of the crushed rock.

ANALYSIS.

	No. 1 G-3889	No. 2 G-3890
Moisture at 104° C.	0.16%	0.45%
Combustible matter	7.35%	7.05%
Sand	92.49%	92.50%
Total	100.00%	100.00%
Bituminous matter soluble in carbon disulfid	6.74%	6.85%

Alfred M. Peter, State Chemist,
Lexington, Ky., Feb. 17, 1920.

EDMONSON COUNTY.

Analysis No. 3.

Laboratory No. G-3968.—Bituminous sandstone (asphalt rock) from the quarries of the Kentucky Asphalt Rock Company on Nolin River in Edmonson County, Ky., brought by Prof. W. R. Jillson, August 24, 1920, the sample having been taken from the same lump from which No. G-3889 was taken.

The sample was about 6 ozs. of bituminous sandstone in several pieces, containing several quartz pebbles.

ANALYSIS.

	Per cent.
Moisture at 104° C.	.35
Combustible matter	8.00
White sand	91.65
Total	100.00
Bituminous matter extracted by carbon disulfid	8.15

(Analysis by W. D. Iler.)
September 20. 1920.

The results show that practically all of the bituminous matter is soluble in carbon disulfid. The excess of the soluble material over the amount obtained by burning may have been caused by the difficulty in weighing two samples of exactly the same composition from material of this character. The residue left on extraction with carbon disulfid was apparently pure white sand.

LOGAN COUNTY.

Analysis No. 4.

Laboratory No. G-4036.—Asphalt rock, labeled "Sample of rock asphalt collected by D. J. Jones, Aug. 19, 1920, north of Russellville, Ky."

Sample, about a 3 lb. lump weathered white on two sides.

ANALYSIS.

	Per cent.
Moisture at 105° C.	0.14
Volatile combustible matter	7.08
Sand	92.78
Total	100.00
Bituminous matter extracted by carbon disulfid	7.61

(Analysis by W. D. Iler.)
December 21, 1920.

CARTER COUNTY.

Analysis No. 5.

Laboratory No. G-4025.—Asphalt rock, labeled "Asphalt impregnated sandstone from quarry on farm of S. M. Bradley, on Mocabee Creek, near Soldier, Carter County, Kentucky. Collected by W. R. Jillson, Nov. 27, 1920."

Sample, a 3-lb. lump.

ANALYSIS.

	Per cent.
Moisture at 105° C.	0.11
Volatile combustible matter	6.53
Sand	93.36
Total	100.00
Bituminous matter extracted by carbon disulfid	7.13

(Analysis by W. D. Iler.)
December 21, 1920.

Analysis No. 6.

Laboratory No. G-4022.—Asphalt rock, labeled "Asphalt impregnated sandstone from fresh quarry face on farm of Mrs. J. P. Danner, Soldier Fork, near Soldier, Carter County, Kentucky. Collected by W. R. Jillson, Nov. 27, 1920."

Sample, 6 lbs. in sack, 2" lumps to powder.

ANALYSIS.

	Per cent.
Moisture at 105° C.	0.07
Volatile combustible matter	3.52
Sand	96.41
Total	100.00
Bituminous matter extracted by carbon disulfid	3.55

(Analysis by W. D. Iler.)
December 21, 1920.

Analysis No. 7.

Laboratory No. G-4024.—Asphalt rock, labeled "Asphalt impregnated sandstone taken from fresh quarry face on the farm of Mrs. J. P. Danner on Soldier Fork, near Soldier, Carter County, Ky. Collected by W. R. Jillson, 11-27-20."

Sample, 2½ pounds, lump. Looks more weathered than the former.

ANALYSIS.

	Per cent.
Moisture at 105° C.	0.06
Volatile combustible matter	3.45
Sand	96.49
Total	100.00
Bituminous matter extracted by carbon disulfid	3.39

(Analysis by W. D. Iler.)
December 21, 1920.

Analysis No. 8.

Laboratory No. G-4023.—Asphalt rock, labeled "Asphalt impregnated sandstone (weathered face of quarry) from farm of Mrs. J. P. Danner, Soldier Fork, near Soldier, Carter County, Ky. Collected by W. R. Jillson, Nov. 27, 1920."

Sample, about 1½ lb. lump.

ANALYSIS.

	Per cent.
Moisture at 105° C.	0.04
Volatile combustible matter	3.43
Sand	96.53
Total	100.00
Bituminous matter extracted by carbon disulfid	4.06

(Analysis by W. D. Iler.)
December 21, 1920.

The above noted physical and chemical characteristics of Kentucky asphalt rock from the Nolin river-Pottsville deposits (Analyses Nos. 1, 2 and 3) are alone responsible for its notable wearing qualities. The low percentage of bitumen in the Carter county sample (analyses 5, 6, 7 and 8) account for its lack of present day commercialization. It is possible, however, that sands low and irregular in asphalt binder, like those of the Carter county section, might eventually be treated by adding small amounts of asphalt, and thus rendered competent and equal to the specifications. Cross sections of roadways made from the Edmonson county product, in hard use for many years, have been examined during a course of experiments, and it has been found that the wear, in most cases, has been almost imperceptible. The complete asphaltic coating of the hard sand grains successfully resists their removal by both wind and water.

Kentucky Rock Asphalt as a surfacing material in a small way has been used for many years. In Buffalo, New York, the first pavement of this material was laid in 1891, and this pavement is still in use, although thirty years have elapsed. In the State of Ohio in 1909, the Nelson Avenue experimental road was laid, composed of seventeen different types of pavements. Today the Kentucky Rock Asphalt section of this road, still in use, is in excellent condition, and has had no repairs. These

IN THE PAINT CREEK GORGE.

A wilderness of small timber coupled with precipitous walls of rock, bad roads and frequent high water make travelling in the Paint Creek Gorge of Johnson County difficult except during the dry periods of the year. Asphalt production in this gorge would have to be a mining proposition and as such the deposits are not regarded as commercial.

two instances afford a fair index to the possible term of life of roads built from Kentucky Rock Asphalt. A specimen taken from the Columbus experiment road and tested by the Pittsburg Testing Laboratories in 1919, showed that aften ten years' usage as a road surfacng material it still contained 7.42 per cent of bitumen. This test of the bitumen content of Kentucky Rock Asphalt. following ten years of exposure, showed the important asphalt binder to be present in the original necessary proportions, and established beyond a question the indestructible qualities of this material.

Rock Asphalt—The Road of First Choice.

A study of the indisputable qualities of adaptability, convenience, cheapness, satisfaction, noiselessness, and life of roads constructed of Kentucky Asphalt Rock will invariably lead to

but one conclusion—first choice. The qualities and virtues of this material are almost without number, and the disadvantages, if any, are inconsequential. The day of better roads for Kentucky and for the nation is at hand. In every city, town and village in this great Commonwealth, men are coming together now to decide what materials shall be used, and in what way the new systems of public roads shall be built. At this important time Kentucky Rock Asphalt, the durable, cheap, and satisfactory road surfacing material, stands pre-eminently on its merits as a great Kentucky mineral resource sufficient in quantity to surface a million miles of new roads, and wholly adequate in quality and cost to please a hundred million exacting taxpayers.

Manuscript completed Feb. 20, 1921.

III.

GEOLOGICAL PROBLEMS IN THE RECOVERY OF OIL AND GAS IN KENTUCKY.*

Differ as we may as to the details or the best and most scientific method of procedure, all geologists are agreed that the greatest problems which now confront the oil and gas producer may be broadly divided into three classes:

(1) Ultimate source of petroliferous hydrocarbons.
(2) Present location of the pool.
(3) Most efficient methods of recovery.

The average producer passes over the first of these classes and gives his attention to the latter two, regarding the first as largely a theoretical matter in which even those petroleum geologists who are the best qualified to speak, are not fully agreed. Yet it does not require the deepest appreciation of this subject to realize that bound up with the solution of the first group of problems, those associating themselves with the determination as to lithological genesis and geologic distribution, is the real key to the science of petroleum geology. When the problems of original source are conquered, many new indexes now but vaguely inferred will be available for use directly in the discovery of new petroleum fields. It will then be possible, and not until then, to divide the earth's minable surface completely and accurately into these three distinct kinds of areas: (1) Producing. (2) Probably productive. (3) Unproductive. Much has already been accomplished in the determination of these three kinds of areas, but it may not be too much to say that many of the fundamental considerations which should control the decision in this regard, have up to the present only been suggested.

What is true with respect to world-wide problems of the geology of oil and gas is also true in the same proportion to any

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*Repub. from Bell. Am. Ass'n of Petroleum Geologists, Vol. 4, No. 3, 1920, pp. 303-312.

restricted area; a formulae devised for one should be applicable to the latter. Kentucky, as the southern tip of the great Appalachian oil and gas field, recognizes the generic problems of this field, to which must be added those of a character induced by the local differences in sedimentation. The geologic problems associated with oil and gas recovery in the Eastern Coal Field of Kentucky are essentially those of West Virginia, with slight modifications, in the same proportion that West Virginia's problems are those of Pennsylvania. These problems have to do with the variance of structure, porosity, saturation, lensing, unconformity, faulting, sequence of sediments, lithology of sediments, depth of sediments, stage of regional metamorphism, devolatilization, degree of concentration, and adequate cover, and their respective combinations. In the consideration of any separate area in Kentucky, none of these factors may be disregarded, and while any of them failing would point toward the condemnation of any certain area, all of them taken together when inferred to be favorable may not, on the basis of past experience, be regarded as more than the separate earmarks of a productive locality.

Speaking in the sense of commercial values rather than in the terms of absolute occurrence, or non-occurrence, two large areas in Kentucky must be designated as barren of petroleum and natural gas. These are: (1) The central Blue Grass area, and (2) That section in western Kentucky between the Tennessee River on the south-west, and the Tradewater River on the north-east. A very large amount of drilling in the Blue Grass section has demonstrated the lack of commercial production in this large section. The absence of commercial petroleum and natural gas here may probably be attributed to the lack of an adequate cover of shale, the surface rocks being Ordovician limestones, which are considerably jointed, faulted and mineralized. The widespread occurrence of small pockets of gas, and occasional shows of oil throughout this area, give evidence of the fact that at one time prior to the denudation of the Devonian cover, much larger quantities of oil and gas were present. The barren strip in western Kentucky between the Tennessee and Tradewater rivers is what is known as the faulted fluorspar section of the state, one associated with ignious intrusion in deeper

seated localities. The absence of commercial quantities of oil and gas in this section may be satisfactorily explained by the large amount of faulting with accompanying devolatilization, and rather high regional metamorphism.

One area alone in Kentucky stands as a unit of possible productivity of commercial quantities of oil and gas, with many important factore yet undetermined. This is the so-called Purchase area, lying between the Tennessee and Mississippi rivers. It is the area at the head of the old Mississippi Embayment, with surficial, unconsolidated sands, gravels, clays and marls of the Tertiary underlain by unconsolidated, and semi-consolidated Cretaceous and older sediments. This area is largely untested, and while the Cretaceous sediments, especially in the southwestern portion might be expected to produce, it is only fair to point out that the area of faulting and ignious activity, which is conspicuously evidenced in the Mississippian exposures, to the northeast in Kentucky, and the north in Illinois, may well extend under the greater part of this area, and render these and lower sediments wholly unproductive. It is also only right to note that this area is one which is associated as a unit with the causes of the New Madrid earthquake. The relationship of this seismic disturbance to the possible productivity of oil and gas, while it has not been definitely determined, may not be regarded as altogether favorable.

With the exception of the three areas above outlined, the entire State of Kentucky may be considered important territory for prospecting for commercial oil and gas. This possible productive and producing territory comprises about three-fourths of the area of the Commonwealth. It includes the eastern and western coal fields and the area lying between them in which Mississippian and Devonian sediments are found at the surface. To this will have to be included a small area along the Cumberland river in southern Kentucky, close to the Tennessee line, where Ordovician sediments have been but recently (geologically) exposed. Over this large area conditions were favorable to the accumulation in disseminated form of petroleum source material, animal and vegetable remains, during Ordovician, Silurian, Devonian, Mississippian and Pennsylvanian times. That there was a grouping of the animal and vegetable life and debris

during those periods, resulting in areas of varying richness, and that there were some areas like the top of the Cincinnati Anticline, which were land surfaces in Onondaga and Niagara times, and therefore barren, cannot be doubted.

The area as a whole, however, is one of continuous, or almost continuous, deposition from the early Ordovician to the latter Pennsylvanian, which fact in itself eliminates many of the problems of original source for the geologist working in this section. As a result of this almost unbroken sedimentation, oil is secured in Kentucky in commercial quantities from the Ordovician, the Silurian, the Devonian, the Mississippian and the Pennsylvanian sediments. This fact will come as a great surprise to many who have read in some books, which for the author's sake should have had some claim to authenticity, that Kentucky oil is principally Trenton oil. Nothing could be more fallacious. Trenton oil in Kentucky is inconsequential in value and in quantity, though present. About ninety-five per cent of the 9,226,473.39 barrels of oil produced in Kentucky in the year 1919 came from the Devonian limestone, immediately underlying the Devonian (Chattanooga) black shale.

With these generalizations, the problems of the oil geologist in Kentucky are hardly suggested, for each separate locality offers peculiarities special to that section, necessitating special consideration. These problems have relatively little bearing, as far as detail goes, with those of the other producing fields of the state. The present commercially productive sections of Kentucky are seven in number, as follows:

(1) The Allen, Barren, Warren fields in southern Kentucky, adjoining Tennessee line.

(2) The Wayne-McCreary fields in south-eastern Kentucky, adjoining Tennessee line.

(3) The Estill, Lee, Powell, Wolfe and Menifee fields, just south-east of the central blue grass area.

(4) The Lawrence county fields.

(5) The Magoffin-Johnson fields.

(6) The Floyd-Knott-Pike-Knox county fields.

(7) Martin county gas field.

The Allen, Barren, Warren fields (Nos. 8, 9, and 10) produce chiefly from the Niagaran limestone of the Silurian, and the Onondaga or Corniferous limestone of the Devonian. The oil occurs in porous places in the limestone proper, no real siliceous sand being present. Structure is apparently an important consideration in such pools as the Gainesville and Moulder. Oil production occurs on the sides and tops of the anticlines and domes. But in southern Allen county, good production is quite as frequently found in the synclines as anticlines, and in this locality the Niagaran limestone is the chief producer. In southeastern Barren county good structures exist which are gassy on top or dry, and the oil seems to be almost synclinal. In northwestern Barren and in Warren county, the Fort Payne (Lower Mississippian) shows real sand lenses, which produce a high grade of "amber oil," and while occasionally structure is important in this horizon, it is more generally a problem of feeling out the ramifications of a lens and then its radiating extensions.

The Wayne-McCreary field (No. 13) in its present development is a rather old one. It is, as a matter of fact, the seat of the first oil ever found in this state, which was discovered on the South Fork of the Cumberland river in 1819 at shallow depths in Mississippian rocks. Though not new, the Wayne-McCreary field has been a consistent and steady producer of high grade green oil, and during the first quarter of 1920 contributed 43,936.07 barrels of crude. Production is secured from the Trenton and higher horizons of the Ordovician from what is known as the Upper and Lower Sunnybrook and Trenton sands. It is also recovered from the Waverly group of sands, shales and limestones in the lower part of the Mississippian. These sands are the "Stray," "Mt. Pisgah," "Beaver," "Otter," 'Cooper" and "Slickford." Well defined anticlines exist in the Wayne county section, but here again the oil is not found high on the structure, but rather well down on the slope, or in the heads of the plunging synclines. As a matter of fact, few reliable conclusions have been reached with respect to petroleum accumulation in the Wayne county section, and while structure apparently is important, it is certainly not the main or only consideration. This is especially true of the irregular "oil sands" found in the Mississippian. Their producing life is remarkable

for its length, but their variability of production and lithology, even within offset distance is so remarkable as to cause the driller as well as the geologist the utmost confusion. These Mississippian sands are apparently connected, or semi-connected lenses, which were whipped up by off-shore currents during the period of deposition They apparently connect with each other vertically as well as laterally, though it may be reasonably inferred that the vertical connection is much more restricted than the other. The Wayne-McCreary fields lie in an off-shore position of the Mississippian seas in which the combination of mud-stone clastics so characteristic of the Waverly to the east and northeast is combined with the growing calcareous tendency of the Warsaw and Fort Payne of southern and western Kentucky. It must have been an ideal locality for the deposition of carbonaceus debris giving rise to an area rich as a petroleum source, but it presents in its irregular sedimentation many unsolved problems to the driller and geologist.

The Estill-Lee-Powell-Wolfe-Menifee section (Nos. 17-27) of Kentucky is the greatest oil and gas producing section of the state. Production has been and still is principally secured from the Onondaga, or Corniferous limestone of the Devonian, directly underlying the Chattanooga black shale. This limestone is frequently called the "Irvine," "Ragland," "Menifee," "Campton" and "Cannel City" sand, but it is in reality simply a dolomitic limestone, oil being secured from porous interspaces in the limestone, not from any siliceous sand as might be inferred from the driller's description. The oil is green and of high gravity, and under relatively little pressure. While structure is present in this field, it apparently is not the principal factor. The oil is found concentrated in the porous places even where it is semi-synclinal, though it occurs in the higher positions as does the Menifee gas where porosity allows of it.

The production in this section has been so great (about 8,500,000 barrels in 1919, or ninety per cent of the entire production of the state) as to raise the very pertinent question as to its ultimate source. The question is more easily asked than answered, though the black (Chattanooga) shale has been ascribed as the mother rock by most geologists. The writer has

never been in concurrence with this explanation for many irrefutable reasons, some of which were advanced as early as July, 1919*. It was then pointed out that the ultimate source of the oil and gas found in the Devonian limestone in this state was not the overlying black (Chattanooga) shale, and that none except very small quantities probably had ever been drawn down to the Onondaga limestone from it. Disregarding the theory of a separate bituminous shale as an essential source, it was stated that the Onondaga limestone itself and the underlying Silurian and Ordovician limestones and shaly limestones were adequate and sufficient in carbonaceous material as a source. The soundness of this argument has recently been attested by the drilling into considerably deeper production in the continuous limestone and shaly limestone series in the heart of the Big Sinking Pool in Lee county, which goes far towards establishing the writer's previously advanced theories concerning the connected relations of the various porous strata in the limestones of this section underlying the black (Devonian-Chattanooga) shale. In this particular section of Kentucky the principle of vertical or semi-vertical movement of the oil has been probably even more important than that of extensive lateral migration. In this section, and in fact all along this western edge of the eastern coal field, the principle of greatly reduced porosity in this magnesian Devonian limestone just before the outcrop is reached has operated frequently to retard the movement of the petroleum and natural gas from further migration toward the north-west and consequent natural dissipation.

The Lawrence county oil fields (No. 4) relatively small in geographic distribution, certainly not large in production, have nevertheless continued to command thoughtful consideration. The oil in this section is a high grade light amber to green, and is produced chiefly from the Berea and Wier sands of the lower Waverly in the Mississippian. The general structure of Lawrence county is that of the head or tip of a deep synclinal trough plunging to the north-east into West Virginia. A number of the productive areas in Lawrence county occur well down in this trough, but newer fields are being developed high on the mono-

*New Oil and Gas Pools of Allen County. Mineral and Forest Resources of Kentucky, Series 5, Vol. 1, No. 2.

clinal fold to the south-west, which is a limb of the pronounced Paint Creek Uplift. The Berea and Wier oil of this section exhibits the characteristic of all of the Mississippian oils of Kentucky, lightness in gravity and color, and a relatively low proportion of sulphur. The producing horizons in this county in both instances are real true siliceous sands, both of which, as well as the overlying and underlying shales, may have been contributing sources of the now contained petroleum and natural gas.

The Johnson-Magoffin oil and gas field (No. 5) located on the crest and sides of the Paint Creek Uplift on the Johnson-Magoffin county line, is perhaps the newest and one of the most interesting fields in Kentucky. In this locality, the "Pottsville," "Big Injun," "Wier" and "Berea" sands, and the "Onondaga" limestone, are all petroliferous. Commercial production is secured, however, only from the Wier sand. This sand is a correlative of the Cuyahoga sandstone of the lower part of the Waverly (Mississippian). It is separated in this section by a shale body from the underlying Berea, which high on the major structure is commercially unimportant, though it is important at lower structural elevations in Johnson county. The reason for the lack of commercial production in the Berea (Mississippian) has not been satisfactorily explained, since it lies so close to the Lawrence county productive fields. Partial saturation of the Berea is perhaps the chief deficient factor. Structure is, however, a principal consideration in this Paint Creek field, the oil occurring on the sides of the pronounced Paint Creek dome, and the top being decidedly gassy. The Paint Creek dome lies as a faulted cap on the elongated north and south Paint Creek Uplift. It is a relatively large structure, the productive portions of which might have been accepted, as mapped on the surface Pottsville coals, to have been rather extensive. It was found, however, in the sequence of drilling operations in this section, that some inexplainable inequalities in the thickness of the various sediments penetrated were being encountered. Detailed consideration of this circumstance gave rise to the fact that the thickness between the top of the Big Lime, or Mountain limestone (Mississippian-St. Louis, St. Genevieve) and the Wier sand (Mississippian) was greater at progressive distances east and west from the crest of the main structure, and to a lesser degree to the

north and to the south. The result of this investigation developed the fact of the occurrence of two folds of different ages beneath this oil field, one toward the close of the Mississippian, and one at the time of the Appalachian revolution. The result of these investigations has been to show that the folding in the Wier sand is much sharper than was anticipated by the mapping of the surface coals. This discovery which was announced by the writer in December, 1919*, explains many of the previously unsolved problems connected with the location of producing wells on this structure.

The Floyd-Knott-Knox oil and gas fields, though disconnected geographically (Nos. 14, 28 and 29), present a unit problem in that production is secured from the "Pottsville" of the Pennsylvanian, and the "Maxon" of the Mauch Chunk. The position of these pools is geosynclinal, but minor structures have influenced to some degree the accumulation. In the Pottsville as well as in the Mauch Chunk, relatively small amounts of water are responsible for the low position of the oil in these sections. In Knox county, the oil is found along rather narrow belts on minor structures, and in Floyd and Knott in basin synclines at the head of a synclinal nose. The gas of Floyd county, however, is anticlinal, as might be expected. Since both of the productive sands in these fields are silicious (sometimes conglomerate) sandstones, the lasting qualities of these sands have been very great. Some of the wells in Floyd county Beaver Creek field have produced for over twenty years. **The oil is green, high gravity, and relatively low in sulphur. In this section, as in the Lawrence county section, the present producing oil sands may be regarded as at least a part of the original petroleum source as well as the underlying and overlying bituminous shales.

The Martin county gas field (No. 34) is considered separately since its producing horizons are distinct. They consist of a sand in the "Big" or Mountain limestone (Mississippian-St. Louis, St. Genevieve), and the "Big Injun" sand group of the Waverly (Mississippian). The field is now an old one, useful

*A Mississippian Island in the Mauch Chunk of Eastern Kentucky. Geol. Sec. A. A. A. St. Louis meeting, Dec., 1919.

**The first oil well in Floyd County was drilled in 1891 by L. H. Gormley of Prestonsburg, at the mouth of Salt Lick on Right Beaver Creek. It is still producing.

for little more than reservoiring purposes, but has been an important one during the past twenty years, having furnished a large part of the commercial supply of gas for the city of Louisville, and other West Virginia, Kentucky and Ohio cities. The productive horizons are true sands. The sand inclusion of the "Big Lime" is relatively thin, but gives a rather high pressure gas, which suggests crevices or joint connection with the underlying "Big Injun" sand. Although a large amount of drilling has been done in this section and these sands have been penetrated at many points, relatively little oil has been found though one or two wells are reported to have flowed under a strong head for a short time. The production of oil in Martin county at present is insignificant, 13.05 barrels being the entire reported production for January, February and March, 1920. In considering the problem of the absence of commercial oil in this section of Kentucky, recourse may be had to a study of the coals and carbon ratios as an index to the amount of regional metaphorism and devolatilization thereby induced. The Martin county section will show a relatively high carbon ratio, as will the section to the south and farther southwest along the Pine mountain fault in Pike, Letcher, Harlan and Bell counties. Of all this section of excellent Pottsville and Mississippian sediments, no commercial quantities of oil or gas fields are known today, even after considerable drilling. Many shows of oil have been secured, and gas in semi-commercial quantities has been found, but a fixed carbon ranging from 64% to 66% giving a corresponding fuel ratio of from 1.8 to 2.00 based on coals sampled at some little distance from the lines of greatest disturbance, is apparently indicative of too great a regional alteration to allow the retention of oil, at least in commercial quantities.

The commercially important group of oil and gas pools now producing as indicated on the accompanying map are thirty-six in number, and are as follows: No. 1. Meade county (old) Gas Field; No. 2 Cloverport (old) Gas Field; No. 3. Hartford Oil Pool; No. 4. Caneyville Oil Pool; No. 5. Leitchfield Oil and Gas Field; No. 6. Bear Creek Gas Field; No. 7. Diamond Springs Gas Field; No. 8. Warren County Oil and Gas Fields; No. 9. Allen County Oil and Gas Fields; No. 10. Barren County Oil and Gas Fields; No. 11. Greensburg Gas

Field; No. 12. Lincoln County Oil Pools; No. 13. Wayne County Oil Pools; No. 14. Knox County Oil and Gas Field; No. 15. Clay County Gas Field; No. 16. Island Creek Gas Field; No. 17. Station Camp Oil Pool; No. 18. Irvine Oil Pool; No. 19. Big Sinking Oil Pool; No. 20. Ross Creek Oil Pool; No. 21. Menifee County Gas Field; No. 22. Menifee County Oil Pool; No. 23. Ragland Oil Pool; No. 24. Campton Oil Pool; No 25. Still Water Oil Pool; No. 26. Breathitt County Gas Field; No. 27. Cannel City Oil and Gas Pool; No. 28. Knott County Oil Pool; No. 29. Beaver Creek Oil and Gas Fields; No. 30. Prestonsburg Oil and Gas Fields; No. 31. Burning Fork Gas Field; No. 32. Paint Creek Oil and Gas Field; No. 33. Laurel Creek Oil and Gas Fields; No. 34. Martin County Gas Field; No. 35. Busseyville Oil Pool; No. 36. Fallsburg Oil Pool.

Any brief consideration of so large a geographic unit as the State of Kentucky must necessarily overlook many of the smaller, though none the less interesting, geologic problems which bear close relationship to the recovery of petroleum and natural gas. Important among these in Kentucky is the cause of the low gravity and asphaltic base of the Ragland or Bath county oils, and the Lincoln county oils. These pools, as is well known, are very shallow, and yet devolatilization alone may not be ascribed as the single cause since other pools in close proximity, producing from the same Devonian limestone, and at a similar depth, give high gravity, green oil. The Allen, Barren, Warren field exhibits in the most of the production secured from below the black or (Chattanooga) shale from either the Devonian or Silurian limestone, a relatively high percentage of sulphur. This is the same horizon that produces the sweet, green oil of the Estill-Lee-Powell-Wolfe-Menifee section, yet the reason for the difference is an unsolved problem. In Grayson, Ohio, McLean, Webster and Union counties along the Rough Creek anticline and fault, similar structural conditions are found to those in eastern Kentucky along the Irvine-Paint Creek fault. In fact these two lines of disturbance with the connecting link

of the deformation in Central Kentucky have been ascribed by Gardner* to a common source, yet this large belt in western Kentucky gives no promise, outside of small quantities of oil in Ohio and Grayson counties, and two small gas fields in Grayson, of any real comparison in productivity to the eastern Kentucky section.

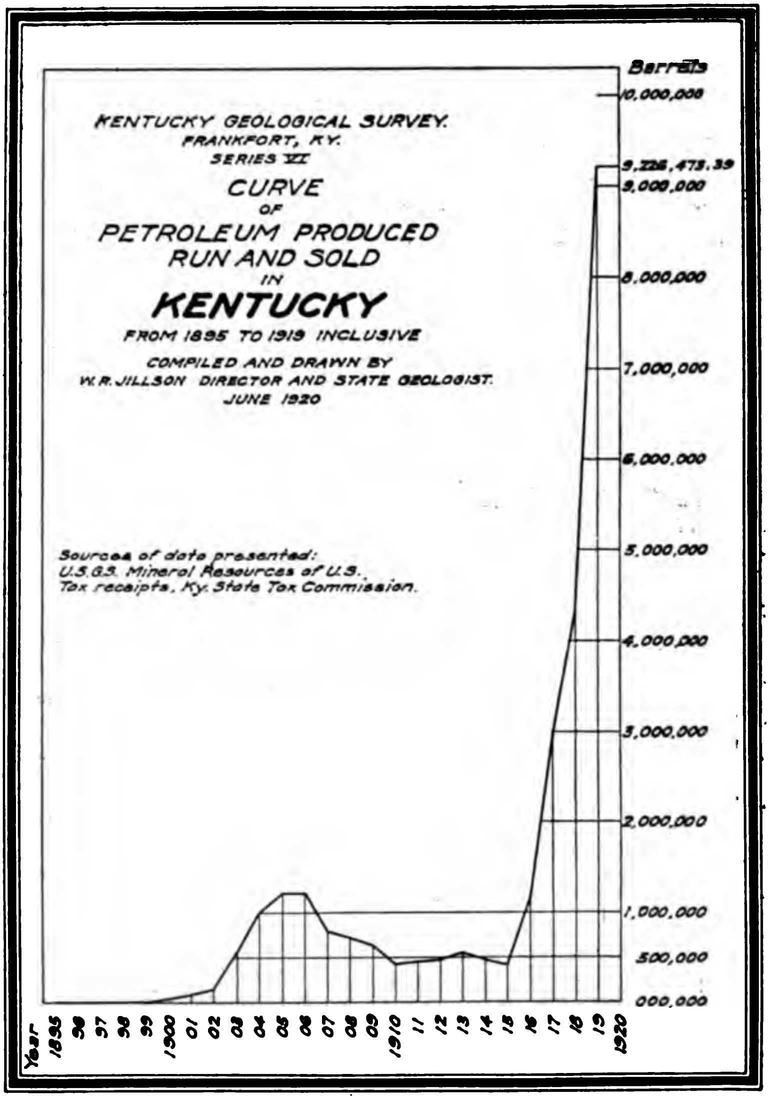
Manuscript completed Sept. 10, 1920.

*A Stratigraphic Disturbance Through the Ohio Valley, Running From the Appalachian Plateau in Pennsylvania, to the Ozark Mountains in Missouri. James H. Gardner, Bulletin G. S. A., Vol. 26, pp. 477-483, Dec., 1915.

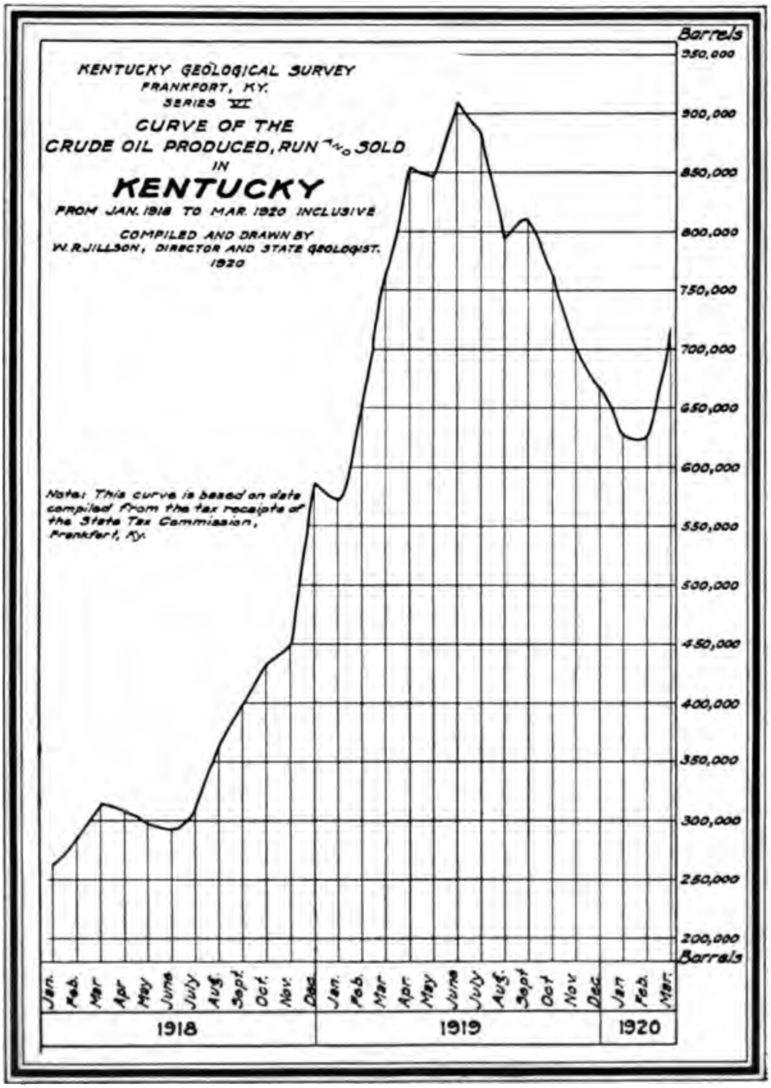
IV.

THE PRODUCTION OF KENTUCKY CRUDE OIL.

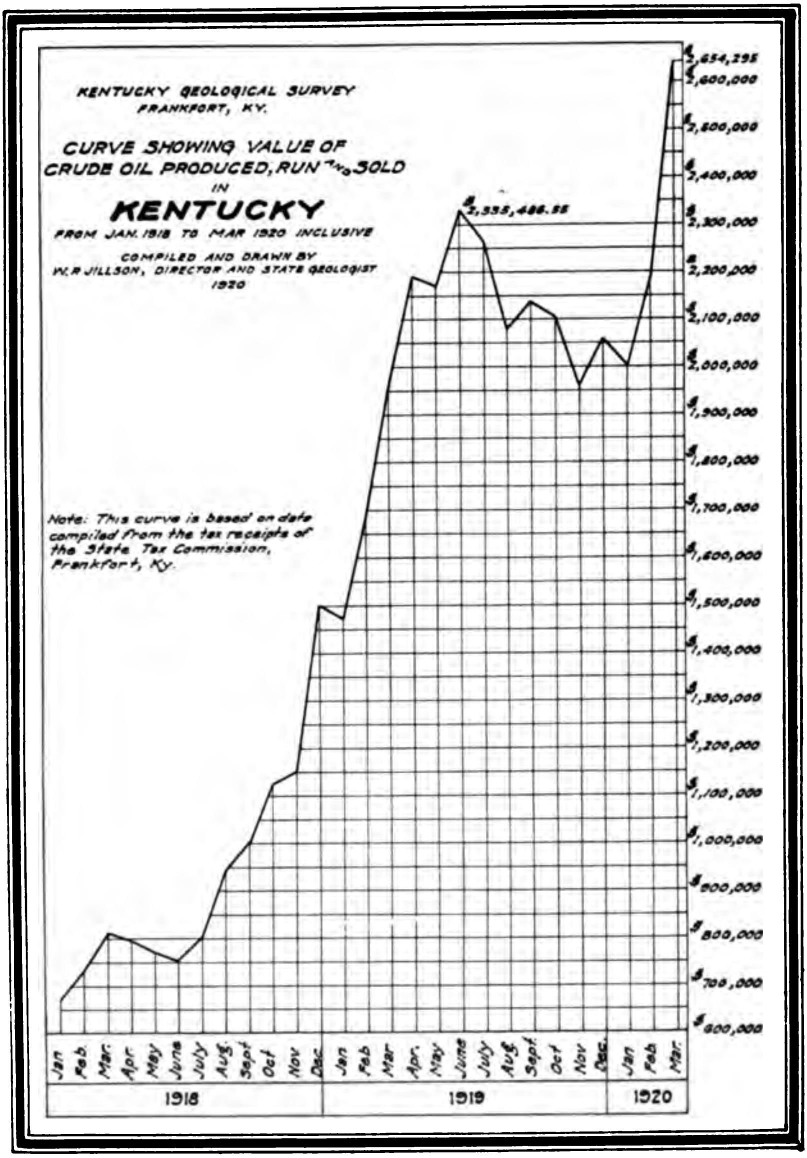
Crude oil, not less than the other necessary mineral resources of Kentucky, has shown during the past two years a development, and an increase in production little short of the mar-



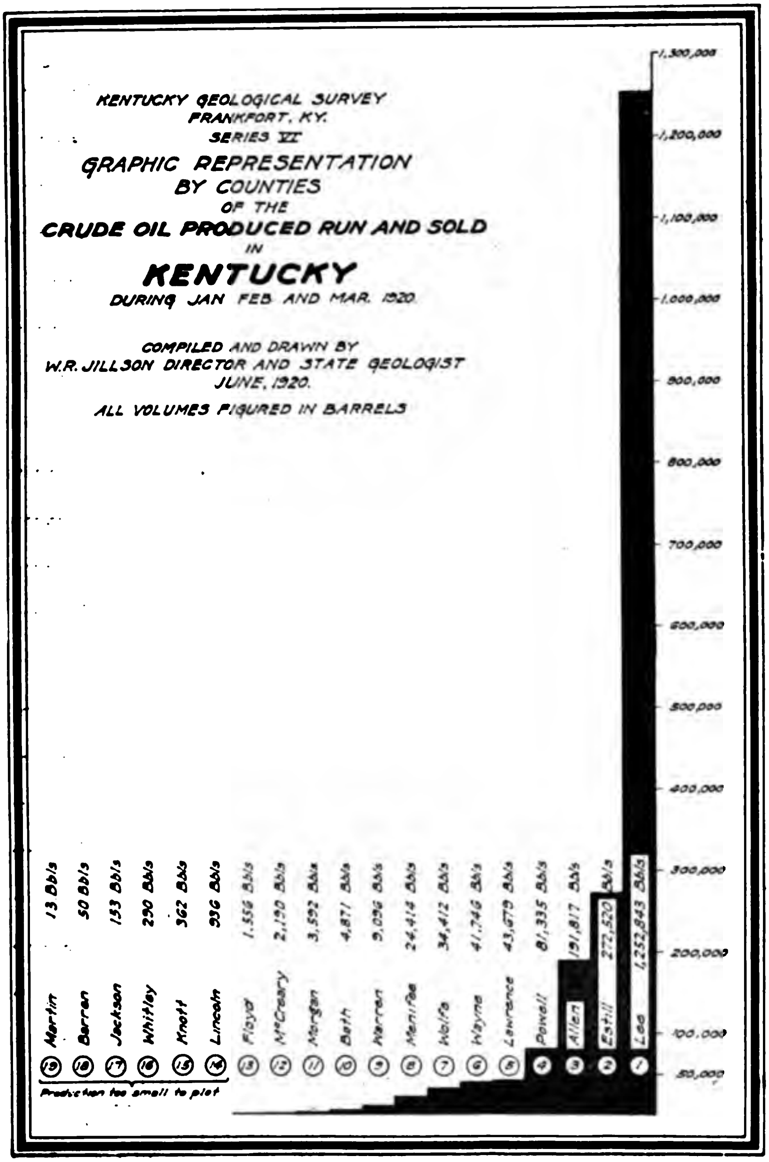
velous. In January, 1918, the production of this state had risen above 200,000 barrels per month, and a steadily increasing monthly production bespoke something of the great increase which was to come. At the close of 1918, the production of Kentucky crude petroleum was 4,350,950 barrels, almost a quadruplication of the production of 1916, which was 1,144,750 barrels.



The peak of petroleum was, however, still to come, and when at the end of the year 1919 the total production of petroleum in this state was placed at 9,229,473, the production of 1918 had



been more than doubled. The peak production of 1919 was reached in June, when 908,948 barrels were produced, with a value of $2,335,486.00.



The year 1920 has seen a great many fluctuations in the production curves of the separate leases, pools and counties. Depletion has recorded itself in several of the largest eastern Kentucky pools, as the production curves of this report, prepared from data generously supplied by the Cumberland Pipe Line Co., and other agencies, mutely testify. This alarming situation is an established fact despite a large increase in number of new wells drilled. Coming to the rescue of a somewhat desperate situation from the standpoint of total petroleum production for the entire state, the new pools of south-western Kentucky in Warren and Simpson counties, and eastern Kentucky in Johnson, Magoffin, Lawrence and Menifee counties, have served to hold off the day of greatly decreased production for the entire state. The total production of 1920, placed at 8,546,027.68 barrels, as compiled from the State Tax Commission records, shows a loss of 680,445.71 barrels as compared to the year 1919. The total value of crude oil produced and sold in Kentucky in the year 1920 was $33,525,210.33 which was an increase of $9,066,-191.59 over the total value of the 1919 oil production.

Herewith are presented the figures in tabular and graphic form showing the production of crude oil in Kentucky to Jan. 1, 1921.

NUMBER OF BARRELS OF OIL PRODUCED AND MARKETED IN KENTUCKY DURING THE YEAR 1920

COUNTY	January	February	March	April	May	June	July
Allen	65,190.72	60,243.06	66,383.22	82,479.00	115,362.39	77,998.30	75,186.18
Barren	....	....	50.80	....	....	....	....
Bath	783.98	2,105.59	1,982.22	1,006.54	1,994.53	1,030.54	1,837.66
Estill	81,780.97	86,280.31	104,459.17	103,392.79	102,059.18	94,134.96	100,288.42
Floyd	606.99	325.01	624.97	416.99	538.98	271.98	549.02
Jackson	....	71.30	82.62	158.00	77.02	182.02	304.01
Johnson	....	....	....	474.98	823.90	1,642.87	2,800.07
Knott	....	362.04	....	....	360.03	....	....
Lawrence	14,308.92	12,880.18	16,490.68	17,117.48	16,122.90	17,400.63	17,260.47
Lee	418,069.06	403,582.96	431,191.31	416,928.67	439,172.43	436,977.33	417,217.57
Lincoln	561.36	....	263.54	1,425.53	639.80	710.26	331.31
McCreary	711.99	522.04	955.98	480.99	618.04	774.94	841.02
Magoffin	....	....	....	....	....	3,093.68	3,183.07
Martin	....	29.76	16.11	16.26	19.45	39.61	76.22
Menifee	....	4,381.19	20,033.74	18,658.10	18,161.94	19,470.62	16,533.46
Morgan	1,354.94	1,009.08	1,228.96	1,251.98	1,893.97	1,384.90	951.06
Powell	24,696.36	26,183.56	30,455.16	29,204.96	28,274.92	27,960.12	26,689.40
Wayne	14,552.08	12,431.08	14,102.96	14,694.30	15,060.10	14,537.48	16,305.02
Warren	1,433.54	4,417.50	6,082.23	6,686.07	11,458.72	16,294.05	28,530.91
Whitley	....	146.31	144.60	142.12	140.56	112.82	....
Wolfe	12,276.97	10,612.10	11,523.85	11,243.96	12,142.95	10,780.23	10,143.26
Simpson	....	....	....	....	....	....	924.54
Total	636,327.88	625,583.07	706,072.12	705,778.82	764,921.80	724,797.34	719,952.67

NUMBER OF BARRELS OF OIL PRODUCED AND MARKETED IN KENTUCKY DURING THE YEAR 1920.
(Continued.)

COUNTY	August	September	October	November	December	Total
Allen	85,915.12	72,756.95	72,987.09	55,110.04	56,555.55	886,167.62
Barren	605.95	277.82	760.25	....	240.02	1,934.84
Bath	1,948.64	1,324.86	1,530.10	1,280.70	1,659.47	18,484.83
Estill	92,623.76	97,667.49	85,477.01	77,869.50	83,749.17	1,109,782.73
Floyd	212.02	546.98	343.00	143.94	645.00	5,124.88
Jackson	167.00	163.02	245.97	232.96	116.04	1,799.96
Johnson	4,421.08	6,186.93	8,483.72	9,524.15	11,018.48	45,376.18
Knott	164.52	....	76.20	....	310.53	1,273.32
Lawrence	18,583.36	21,600.60	20,934.48	20,962.60	24,013.24	217,675.54
Lee	444,610.16	417,395.50	440,410.69	424,487.53	438,357.91	5,128,401.12
Lincoln	....	284.98	95.41	94.95	82.52	4,489.66
McCreary	516.08	749.96	498.02	515.02	863.05	8,047.13
Magoffin	3,662.07	5,860.91	7,042.50	13,250.13	15,468.58	51,560.94
Martin	8.96	28.13	....	....	....	234.60
Menifee	15,613.30	12,141.82	9,886.31	10,190.20	7,809.25	152,879.93
Morgan	1,448.05	1,020.98	1,389.86	1,013.92	1,031.00	14,978.70
Powell	26,336.76	26,352.22	25,461.32	27,180.99	22,987.55	321,783.32
Wayne	13,502.29	14,886.49	14,933.80	20,664.67	25,562.68	191,232.95
Warren	34,107.13	44,432.14	43,999.60	33,493.55	22,008.71	252,944.15
Whitley	140.37	148.39	....	145.70	....	1,120.86
Wolfe	9,291.19	9,328.86	9,670.85	8,902.76	9,251.96	125,168.94
Simpson	1,218.64	1,195.51	629.91	971.10	625.78	5,565.48
Total	755,096.45	734,350.54	744,856.09	706,034.41	722,256.49	8,546,027.68

AMOUNT RECEIVED FROM PRODUCTION OF OIL IN KENTUCKY DURING THE YEAR 1920.

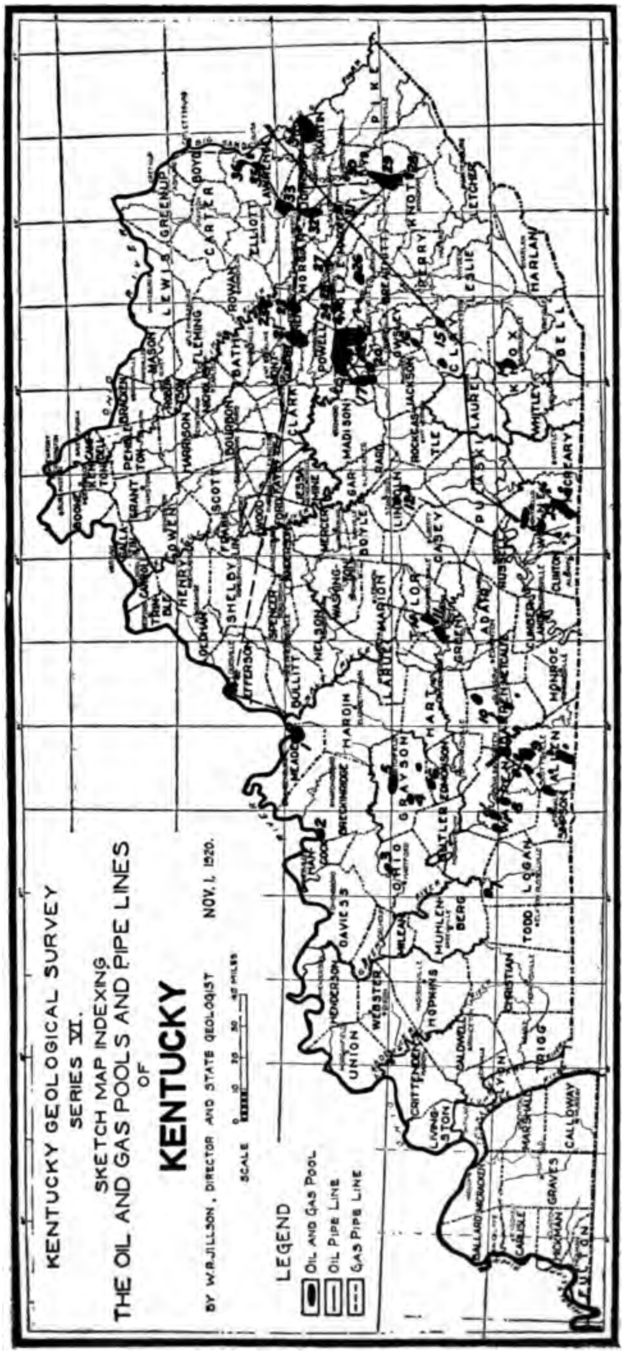
COUNTY	January	February	March	April	May	June	July
Allen	$186,790.00	$177,432.97	$224,047.55	$280,840.78	$397,459.17	$269,094.48	$260,552.49
Barren	....	....	175.26	....	....	....	....
Bath	1,371.96	3,684.78	3,468.88	2,113.13	4,198.51	2,164.13	4,318.50
Estill	265,686.49	318,452.00	391,626.55	411,416.99	407,645.68	376,539.84	401,153.68
Floyd	1,973.32	1,218.79	2,343.74	1,667.96	2,155.92	1,087.92	2,196.08
Jackson	....	267.38	309.82	632.00	308.08	728.08	1,216.04
Johnson	....	....	....	1,899.92	3,295.60	6,571.48	11,200.28
Knott	....	1,357.66	....	....	1,440.12	....	....
Lawrence	45,504.00	48,300.68	61,840.05	68,469.92	64,491.60	69,602.52	69,041.88
Lee	1,358,670.00	1,435,798.40	1,615,896.82	1,600,223.98	1,744,689.50	1,751,006.36	1,672,318.03
Lincoln	1,712.16	....	935.97	5,702.12	2,559.20	2,667.77	778.58
McCreary	2,313.97	1,956.67	3,584.93	1,923.96	2,472.16	3,099.76	3,364.08
Magoffin	....	....	....	....	....	12,375.22	12,732.28
Martin	....	101.78	63.15	64.13	81.11	165.17	317.83
Menifee	....	16,429.46	75,126.53	74,632.40	72,647.76	77,882.48	66,133.84
Morgan	4,403.56	3,784.05	4,608.60	5,007.92	7,575.88	5,539.60	3,804.24
Powell	80,452.10	96,069.77	114,207.84	115,977.04	112,860.12	111,840.48	106,757.60
Wayne	47,294.18	46,358.89	52,875.81	58,634.66	60,208.90	58,149.92	65,220.08
Warren	4,158.11	13,020.25	20,421.21	23,009.02	41,203.26	69,053.32	104,328.91
Whitley	....	548.66	542.22	568.48	562.20	451.28	....
Wolfe	39,900.15	39,795.38	43,216.44	45,075.84	48,571.80	43,120.92	40,573.04
Simpson	....	....	....	....	....	....	3,698.16
Total	$2,040,230.00	$2,204,567.56	$2,615,291.37	$2,697,860.24	$2,974,426.57	$2,851,130.73	$2,829,705.62

AMOUNT RECEIVED FROM PRODUCTION OF OIL IN KENTUCKY DURING THE YEAR 1920.
(Continued.)

COUNTY	August	September	October	November	December	Total
Allen	$298,109.57	$251,928.05	$285,991.48	$215,674.47	$221,527.24	$3,069,448.25
Barren	2,122.36	1,021.98	2,052.68	....	948.79	6,321.07
Bath	4,818.42	3,444.64	3,993.56	3,329.82	3,733.80	40,640.13
Estill	370,495.04	413,372.07	366,942.87	335,952.21	341,671.32	4,400,954.74
Floyd	848.08	2,324.66	1,493.37	629.43	2,213.99	20,153.26
Jackson	668.00	692.83	1,045.37	990.07	464.16	7,321.83
Johnson	17,684.32	26,294.45	37,060.72	41,910.49	46,067.01	191,984.27
Knott	658.08	....	323.85	....	1,284.25	5,063.95
Lawrence	74,333.44	91,802.55	92,097.80	93,500.27	101,466.73	880,451.44
Lee	1,782,407.05	1,719,165.68	1,943,445.37	1,916,030.98	1,916,587.65	20,465,239.82
Lincoln	....	740.95	367.32	246.87	185.67	15,886.61
McCreary	2,064.32	3,187.33	2,116.58	2,188.84	3,452.20	31,724.80
Magoffin	14,648.28	24,908.87	29,930.62	56,313.06	61,874.32	212,782.64
Martin	37.36	117.30	....	....	....	947.83
Menifee	62,453.20	51,602.74	42,016.81	43,410.25	31,237.08	613,572.55
Morgan	5,792.20	4,339.17	5,960.47	4,374.50	4,190.49	59,380.68
Powell	105,347.04	110,359.42	110,933.71	120,345.83	96,741.13	1,281,882.08
Wayne	54,009.56	63,186.98	65,410.99	92,024.77	107,930.46	771,304.19
Warren	124,722.10	164,356.54	169,096.19	127,397.17	85,211.17	935,977.25
Whitley	561.48	630.65	....	619.23	....	4,484.20
Wolfe	37,164.76	39,647.65	42,509.56	39,526.53	38,818.31	497,920.38
Simpson	4,879.56	4,782.04	2,944.87	3,224.06	2,344.68	21,866.36
Total	$2,963,819.22	$2,977,905.55	$3,205,734.19	$3,096,688.83	$3,067,850.45	$33,525,210.33

INDIAN REFINING COMPANY—KENTUCKY RUNS.

MONTH	Scottsville		Rodemer		Bowling Green		Eastern Kentucky	
	Runs	Shipments	Runs	Shipments	Runs	Shipments	Runs	Shipments
1919								
Jan.	10,904.70	9,994.44	5,755.50	5,755.56	....	....	18,191.57	21,001.64
Feb.	16,859.96	17,212.75	7,501.84	7,753.31	....	....	32,367.90	38,516.97
Mar.	22,018.76	23,117.79	11,394.35	12,214.98	....	....	37,060.46	92,473.09
April	28,228.35	29,307.60	17,215.96	18,139.13	....	....	38,482.00	45,127.77
May	35,743.78	35,665.19	15,239.67	16,437.24	....	....	49,183.33	5,477.17
June	34,538.18	36,318.34	16,227.71	19,450.07	....	....	51,732.74	45,712.77
July	39,951.58	37,038.39	28,000.35	25,165.03	....	....	59,255.48	72,746.32
Aug.	38,610.69	40,301.30	15,031.63	15,661.56	....	....	62,842.64	66,301.85
Sept.	46,703.72	46,285.27	14,323.07	14,788.21	....	....	72,732.43	81,589.78
Oct.	53,028.50	52,112.32	17,153.76	16,757.71	....	....	72,768.22	77,997.28
Nov.	43,819.60	43,913.79	12,541.72	13,382.98	....	....	72,580.68	79,516.50
Dec.	48,728.97	49,171.80	11,032.98	11,416.01	....	....	76,944.86	60,841.53
1920								
Jan.	49,650.51	51,214.95	11,914.86	12,655.78	....	....	72,974.03	60,204.52
Feb.	48,463.49	48,421.33	12,051.95	12,461.46	....	....	76,896.02	68,225.40
Mar.	52,816.07	44,003.50	13,495.10	12,871.95	....	....	87,285.51	93,822.33
April	47,973.44	60,507.00	14,167.16	15,021.28	....	....	88,165.78	99,844.51
May	59,608.78	59,243.93	14,413.82	14,839.53	....	....	104,062.36	93,668.30
June	67,044.27	62,117.17	15,996.52	16,953.42	....	....	100,171.12	94,472.28
July	56,330.07	54,679.33	11,233.26	20,858.05	....	....	87,518.86	94,504.27
Aug.	53,606.91	54,982.12	23,241.01	20,976.89	1,073.70	2,812.39	84,920.24	67,120.93
Sept.	55,049.23	61,326.17	13,660.10	19,143.73	8,007.58	5,731.41	90,100.87	74,122.55
Oct.	51,979.47	46,876.76	20,099.39	19,484.48	11,739.83	14,459.22	112,030.07	69,961.98


KENTUCKY GEOLOGICAL SURVEY
SERIES VI.
SKETCH MAP INDEXING
THE OIL AND GAS POOLS AND PIPE LINES
OF
KENTUCKY
BY W.R. JILLSON, DIRECTOR AND STATE GEOLOGIST
NOV. 1, 1920.
SCALE
LEGEND
OIL AND GAS POOL
OIL PIPE LINE
GAS PIPE LINE

STATEMENT SHOWING PRODUCTION OF CRUDE PETROLEUM IN THE STATE OF KENTUCKY DURING THE YEARS 1918, 1919 AND 1920.

MONTH	1918		1919		1920	
	Bbls.	Value	Bbls.	Value	Bbls.	Value
January			572,161.05	$1,474,158.98	636,327.88	$2,040,230.00
February	864,272.55	$2,221,998.77	653,652.43	1,684,176.76	625,583.07	2,204,567.56
March				1,960,145.96	706,072.12	2,615,291.37
April	308,084.33	798,385.66	855,296.74	2,198,913.06	705,778.82	2,697,860.24
May	298,021.44	771,956.00	846,065.30	2,171,387.00	764,921.80	2,974,426.57
June	292,315.33	758,472.89	908,948.19	2,335,486.55	724,797.34	2,851,130.73
July	310,394.27	802,225.31	885,653.30	2,266,960.05	719,952.67	2,829,705.62
August	365,044.82	945,076.25	794,057.74	2,088,067.00	755,096.45	2,963,819.22
September	399,740.64	1,035,027.94	811,231.67	2,145,653.00	734,350.54	2,977,905.55
October	435,141.99	1,124,683.00	767,562.54	2,102,310.00	744,856.09	3,205,734.19
November	446,970.90	1,151,248.78	700,340.71	1,961,985.00	706,034.41	3,096,688.83
December	588,906.76	1,519,347.00	670,353.23	2,069,774.00	722,256.49	3,067,850.45
Totals	4,308,893.03	$11,128,421.60	9,226,473.39	$24,459,017.36	8,546,027.68	$33,525,210.33

OIL RUNS OF JANUARY, 1921.

In spite of the drop in the price of crude Kentucky oil runs for the month of January, 1921, totaling 744,278.99 barrels, show an increase over December, 1920, of 22,024.50 barrels. Warren, Johnson, Magoffin and Wayne Counties show increases. December runs from Warren were only 22,000 barrels, while those of January, 1921, were almost 60,000. Small decreases are shown in both Lee and Estill Counties in Eastern Kentucky.

RUNS OF KENTUCKY BY COUNTIES FOR JANUARY, 1921.

County.	Barrels.
Allen	56,980.56
Bath	1,488.28
Estill	77,384.09
Floyd	196.95
Jackson	329.96
Johnson	14,119.46
Knott	61.42
Lawrence	22,474.69
Lee	418,807.84
Lincoln	94.26
Magoffin	19,818.10
Menifee	7,786.31
Morgan	1,764.66
McCreary	548.90
Powell	23,052.92
Simpson	680.06
Warren	59,906.66
Wayne	30,202.57
Whitley	137.69
Wolfe	8,443.61
Total barrels	743,598.93

STATEMENT SHOWING PRODUCTION OF OIL IN THE STATE OF KENTUCKY BY MONTHS DURING THE YEAR 1918 IN THE FOLLOWING NAMED COUNTIES

	Allen		Barren		Bath		Estill	
	Bbls.	Value.	Bbls.	Value.	Bbls.	Value.	Bbls.	Value.
January	....	....	....	....	....	....	....	....
February	....	....	....	....	....	....	....	....
March	....	....	....	....	....	....	....	....
April	....	....	....	....	1,933.76	$2,419.00	181,748.80	$472,548.61
May	....	....	....	....	2,160.48	2,702.00	159,484.75	414,664.00
June	5,462.06	$14,201.00	294.50	$589.00	1,034.86	1,296.00	145,361.28	378,133.02
July	3,115.37	6,517.40	119.00	309.40	2,372.52	2,964.00	142,044.64	369,830.54
August	3,855.68	8,195.95	80.00	210.50	1,679.33	2,100.00	140,141.19	364,386.00
September	2,636.83	5,151.59	118.00	320.00	2,370.75	3,734.00	147,810.43	384,302.00
October	6,833.67	14,267.00	252.12	655.00	1,637.03	2,212.00	154,030.75	400,494.00
November	17,403.55	35,951.36	166.88	470.00	1,497.47	2,435.00	134,974.81	350,942.00
December	17,904.15	37,830.00	....	....	2,538.26	3,532.00	241,680.00	628,362.00
Totals	57,211.31	$122,114.30	1,030.50	$2,553.90	17,224.46	$23,394.00	1,447,266.65	$3,763,662.17

STATEMENT SHOWING PRODUCTION OF OIL IN THE STATE OF KENTUCKY BY MONTHS DURING THE YEAR 1918 IN THE FOLLOWING NAMED COUNTIES

	Floyd		Knott		Lawrence		Lee	
	Bbls.	Value.	Bbls.	Value.	Bbls.	Value.	Bbls.	Value.
January	....	....	....	....	....	....	....	....
February	....	....	....	....	....	....	....	....
March	....	....	....	....	....	....	....	....
April	866.64	$2,253.00	28.52	$74.15	5,924.76	$15,402.00	10,738.56	$27,918.00
May	668.99	1,739.00	161.99	426.00	6,302.87	16,390.00	22,985.53	59,764.00
June	370.05	962.00	....	....	5,872.80	15,272.00	39,933.54	103,825.02
July	496.05	770.00	239.02	621.00	6,177.10	16,062.00	59,954.55	155,881.10
August	613.95	1,597.00	....	....	5,602.69	14,570.00	126,912.91	329,992.00
September	345.02	897.00	....	....	5,751.90	14,950.00	156,320.20	406,422.00
October	749.98	1,950.00	175.02	452.00	5,888.85	15,308.00	186,961.61	486,126.00
November	542.96	1,408.00	....	....	5,371.91	13,968.00	221,246.97	575,198.00
December	424.06	1,102.00	171.96	394.00	6,167.94	16,036.00	251,908.47	654,979.00
Totals	5,077.70	$12,678.00	776.51	$1,967.15	53,060.82	$137,958.00	1,076,962.34	$2,800,105.12

STATEMENT SHOWING PRODUCTION OF OIL IN THE STATE OF KENTUCKY BY MONTHS DURING THE YEAR 1918 IN THE FOLLOWING NAMED COUNTIES

	Lincoln		Martin		McCreary	
	Bbls.	Value.	Bbls.	Value.	Bbls.	Value.
January	....	....	....	....	....	....
February	....	....	....	....	....	....
March	....	....	....	....	....	....
April	....	....	....	....	1,196.95	$3,112.00
May	....	....	....	....	1,188.98	3,092.00
June	....	....	....	....	910.63	2,368.00
July	....	....	....	....	1,041.02	2,706.00
August	....	....	....	....	751.94	1,956.00
September	....	....	....	....	685.02	1,781.00
October	....	....	1,359.69	$3,644.00	860.02	2,236.00
November	1,222.26	$3,055.65	44.55	123.40	678.10	1,762.00
December	734.08	1,909.00	....	....	774.02	2,032.00
Totals	1,956.34	$4,964.65	1,404.24	$3,767.40	8,086.68	$21,045.00

STATEMENT SHOWING PRODUCTION OF OIL IN THE STATE OF KENTUCKY BY MONTHS DURING THE YEAR 1918 IN THE FOLLOWING NAMED COUNTIES

	Morgan		Ohio		Powell	
	Bbls.	Value.	Bbls.	Value.	Bbls.	Value.
January	....	....	....	....	....	....
February	....	....	....	....	....	....
March	....	....	....	....	....	....
April	2,039.35	$5,294.32	....	....	83,690.81	$217,571.00
May	1,692.96	4,400.00	....	....	81,764.33	212,592.00
June	1,562.95	4,062.00	....	....	72,407.54	188,267.91
July	1,979.03	5,142.00	....	....	71,589.49	186,124.29
August	1,259.93	3,270.00	....	....	62,859.51	163,446.00
September	1,445.06	3,754.00	727.69	$1,745.95	59,343.69	154,289.00
October	1,409.97	3,666.00	1,472.01	2,536.00	52,218.48	135,770.00
November	1,376.80	3,578.00	....	....	42,465.94	110,410.37
December	1,509.96	3,926.00	219.00	570.00	44,472.60	115,628.00
Totals	14,276.01	$37,092.32	2,418.70	$4,851.95	570,812.39	$1,484,098.57

STATEMENT SHOWING PRODUCTION OF OIL IN THE STATE OF KENTUCKY BY MONTHS DURING THE YEAR 1918 IN THE FOLLOWING NAMED COUNTIES

	Allen		Barren		Bath		Estill	
	Bbls.	Value.	Bbls.	Value.	Bbls.	Value.	Bbls.	Value.
January								
February								
March								
April					1,933.76	$2,419.00	181,748.80	$472,548.61
May					2,160.48	2,702.00	159,484.75	414,664.00
June	5,462.06	$14,201.00	294.50	$589.00	1,034.86	1,296.00	145,361.28	378,133.02
July	3,115.37	6,517.40	119.00	309.40	2,372.52	2,964.00	142,044.64	369,830.54
August	3,855.68	8,195.95	80.00	210.50	1,679.33	2,100.00	140,141.19	364,386.00
September	2,636.83	5,151.59	118.00	320.00	2,370.75	3,734.00	147,810.43	384,302.00
October	6,833.67	14,267.00	252.12	655.00	1,637.03	2,212.00	154,030.75	400,494.00
November	17,403.55	35,951.36	166.88	470.00	1,497.47	2,435.00	134,974.81	350,942.00
December	17,904.15	37,830.00			2,538.26	3,532.00	241,680.00	628,362.00
Totals	57,211.31	$122,114.30	1,030.50	$2,553.90	17,224.46	$23,394.00	1,447,266.65	$3,763,662.17

STATEMENT SHOWING PRODUCTION OF OIL IN THE STATE OF KENTUCKY BY MONTHS DURING THE YEAR 1918 IN THE FOLLOWING NAMED COUNTIES

	Floyd		Knott		Lawrence		Lee	
	Bbls.	Value.	Bbls.	Value.	Bbls.	Value.	Bbls.	Value.
January	....	....	....	....	....	....	....	....
February	....	....	....	....	....	....	....	....
March	....	....	....	....	....	....	....	....
April	866.64	$2,253.00	28.52	$74.15	5,924.76	$15,402.00	10,738.56	$27,918.00
May	668.99	1,739.00	161.99	426.00	6,302.87	16,390.00	22,985.53	59,764.00
June	370.05	962.00	....	....	5,872.80	15,272.00	39,933.54	103,825.02
July	496.05	770.00	239.02	621.00	6,177.10	16,062.00	59,954.55	155,881.10
August	613.95	1,597.00	....	....	5,602.69	14,570.00	126,912.91	329,992.00
September	345.02	897.00	....	....	5,751.90	14,950.00	156,320.20	406,422.00
October	749.98	1,950.00	175.02	452.00	5,888.85	15,308.00	186,961.61	486,126.00
November	542.96	1,408.00	....	....	5,371.91	13,968.00	221,246.97	575,198.00
December	424.06	1,102.00	171.96	394.00	6,167.94	16,036.00	251,908.47	654,979.00
Totals	5,077.70	$12,678.00	776.51	$1,967.15	53,060.82	$137,958.00	1,076,962.34	$2,800,105.12

STATEMENT SHOWING PRODUCTION OF OIL IN THE STATE OF KENTUCKY BY MONTHS DURING THE YEAR 1918 IN THE FOLLOWING NAMED COUNTIES

	Lincoln		Martin		McCreary	
	Bbls.	Value.	Bbls.	Value.	Bbls.	Value.
January	....	....	....	....	....	....
February	....	....	....	....	....	....
March	....	....	....	....	....	....
April	....	....	....	....	1,196.95	$3,112.00
May	....	....	....	....	1,188.98	3,092.00
June	....	....	....	....	910.63	2,368.00
July	....	....	....	....	1,041.02	2,706.00
August	....	....	....	....	751.94	1,956.00
September	....	....	....	....	685.02	1,781.00
October	....	....	1,359.69	$3,644.00	860.02	2,236.00
November	1,222.26	$3,055.65	44.55	123.40	678.10	1,762.00
December	734.08	1,909.00	....	....	774.02	2,032.00
Totals	1,956.34	$4,964.65	1,404.24	$3,767.40	8,086.68	$21,045.00

STATEMENT SHOWING PRODUCTION OF OIL IN THE STATE OF KENTUCKY BY MONTHS DURING THE YEAR 1918 IN THE FOLLOWING NAMED COUNTIES

	Morgan		Ohio		Powell	
	Bbls.	Value.	Bbls.	Value.	Bbls.	Value.
January	....	....	....	....	....	....
February	....	....	....	....	....	....
March	....	....	....	....	....	....
April	2,039.35	$5,294.32	....	....	83,690.81	$217,571.00
May	1,692.96	4,400.00	....	....	81,764.33	212,592.00
June	1,562.95	4,062.00	....	....	72,407.54	188,267.91
July	1,979.03	5,142.00	....	....	71,589.49	186,124.29
August	1,259.93	3,270.00	....	....	62,859.51	163,446.00
September	1,445.06	3,754.00	727.69	$1,745.95	59,343.69	154,289.00
October	1,409.97	3,666.00	1,472.01	2,536.00	52,218.48	135,770.00
November	1,376.80	3,578.00	....	....	42,465.94	110,410.37
December	1,509.96	3,926.00	219.00	570.00	44,472.60	115,628.00
Totals	14,276.01	$37,092.32	2,418.70	$4,851.95	570,812.39	$1,484,098.57

STATEMENT SHOWING PRODUCTION OF OIL IN THE STATE OF KENTUCKY BY MONTHS DURING THE YEAR 1918 IN THE FOLLOWING NAMED COUNTIES

	Wayne		Whitley		Wolfe	
	Bbls.	Value.	Bbls.	Value.	Bbls.	Value.
January	....	....	....	....	....	....
February	....	....	....	....	....	....
March	....	....	....	....	....	....
April	14,195.42	$36,915.58	....	....	5,720.76	$14,878.00
May	14,182.71	36,872.00	....	....	7,427.85	19,315.00
June	13,207.57	34,141.90	149.58	$390.00	5,757.97	14,965.04
July	15,515.80	40,339.58	295.59	772.00	5,455.09	14,186.00
August	13,154.30	34,203.80	149.77	391.00	7,983.62	20,758.00
September	13,546.40	35,217.40	149.41	390.00	8,490.24	22,074.00
October	13,263.99	34,48900	....	....	8,028.80	20,878.00
November	12,029.82	31,277.00	....	....	7,948.88	20,670.00
December	12,025.34	31,265.00	....	....	8,376.92	21,782.00
Totals	121,121.35	$314,721.26	744.35	$1,943.00	65,190.13	$169,506.04

STATEMENT SHOWING PRODUCTION OF OIL IN THE STATE OF KENTUCKY BY MONTHS DURING THE YEAR 1919 IN THE FOLLOWING NAMED COUNTIES

	Allen		Barren		Bath		Cumberland	
	Bbls.	Value.	Bbls.	Value.	Bbls.	Value.	Bbls.	Value.
January	16,174.44	$30,370.60	....	....	1,324.36	$1,654.00	....	....
February	25,282.44	53,112.14	....	....	1,985.99	2,482.00	....	....
March	33,172.49	69,686.00	....	....	1,631.27	2,238.00	....	....
April	45,092.05	94,638.00	268.26	$523.10	1,338.55	1,672.00	....	....
May	51,593.57	108,422.00	....	....	1,839.08	2,297.00	....	....
June	50,333.71	105,702.00	....	....	1,851.75	2,314.00	....	....
July	67,450.05	141,648.00	....	....	1,508.03	1,882.00	....	....
August	53,199.06	111,719.00	....	....	2,052.89	2,566.00	....	....
September	60,455.90	131,859.00	....	....	1,514.82	1,892.00	80.00	$176.00
October	70,729.75	155,346.00	144.96	319.00	1,369.97	1,850.00	....	....
November	57,250.25	130,264.00	....	....	1,695.19	2,288.00	....	....
December	59,558.53	150,949.00	....	....	1,836.74	3,211.00	136.00	387.00
Totals	590,292.24	$1,283,715.74	413.22	$842.10	19,948.64	$26,346.00	216.00	$563.00

STATEMENT SHOWING PRODUCTION OF OIL IN THE STATE OF KENTUCKY BY MONTHS DURING THE YEAR 1919 IN THE FOLLOWING NAMED COUNTIES

	Estill		Floyd		Jackson		Knott	
	Bbls.	Value.	Bbls.	Value.	Bbls.	Value.	Bbls.	Value.
January	122,674.13	$318,964.00	587.02	$1,646.00	....	....	....	....
February	122,617.04	318,780.00	450.98	1,172.00	187.26	$486.00	....	....
March	112,010.06	291,214.00	718.02	1,866.00	750.03	1,950.00	113.01	$295.00
April	113,811.29	295,901.00	818.96	2,128.00	122.54	378.00	....	....
May	100,198.54	260,507.00	334.10	870.00	....	....	....	....
June	114,236.79	296,318.00	410.02	1,790.00	....	....	....	....
July	107,884.95	280,520.00	650.96	1,690.00	83.96	212.00	113.80	290.00
August	99,667.37	268,564.00	413.02	1,134.00	....	....	73.92	198.00
September	97,026.65	261,910.00	836.02	2,256.00	....	....	410.96	1,110.00
October	102,896.70	292,010.00	327.02	932.00	....	....	185.03	527.00
November	86,625.09	246,674.00	692.90	1,975.00	279.02	796.00	190.92	544.00
December	84,281.60	271,744.00	110.98	360.00	....	....	264.97	866.00
Totals	1,263,930.21	$3,403,106.00	6,350.00	$17,819.00	1,422.81	$3,822.00	1,352.61	$3,830.00

STATEMENT SHOWING PRODUCTION OF OIL IN THE STATE OF KENTUCKY BY MONTHS DURING THE YEAR 1919 IN THE FOLLOWING NAMED COUNTIES

	Lawrence		Lee		Martin	
	Bbls.	Value.	Bbls.	Value.	Bbls.	Value.
January	6,330.92	$16,458.00	353,354.70	$918,726.00	....	....
February	5,404.76	14,056.00	436,559.97	1,135,098.00	....	....
March	7,443.22	19,354.00	539,913.46	1,403,704.21	69.02	$191.17
April	6,371.86	16,566.00	619,012.53	1,609,386.00	....	....
May	7,981.05	20,754.00	618,258.88	1,607,498.00	15.87	44.00
June	6,777.08	17,618.00	672,531.07	1,748,559.00	17.62	48.80
July	6,932.55	18,022.00	639,772.75	1,663,463.00	....	....
August	8,123.22	21,934.00	570,152.39	1,519,879.00	....	....
September	7,544.89	20,374.00	568,946.10	1,534,973.00	91.73	258.00
October	8,417.35	23,992.00	514,262.62	1,432,362.00	....	....
November	11,796.83	33,618.00	486,579.06	1,389,504.00	....	....
December	11,468.68	37,278.00	457,245.34	1,427,724.00	34.12	105.00
Totals	94,592.41	$260,024.00	6,476,588.87	$17,390,876.21	$228.36	$646.97

STATEMENT SHOWING PRODUCTION OF OIL IN THE STATE OF KENTUCKY BY MONTHS DURING THE YEAR 1919 IN THE FOLLOWING NAMED COUNTIES

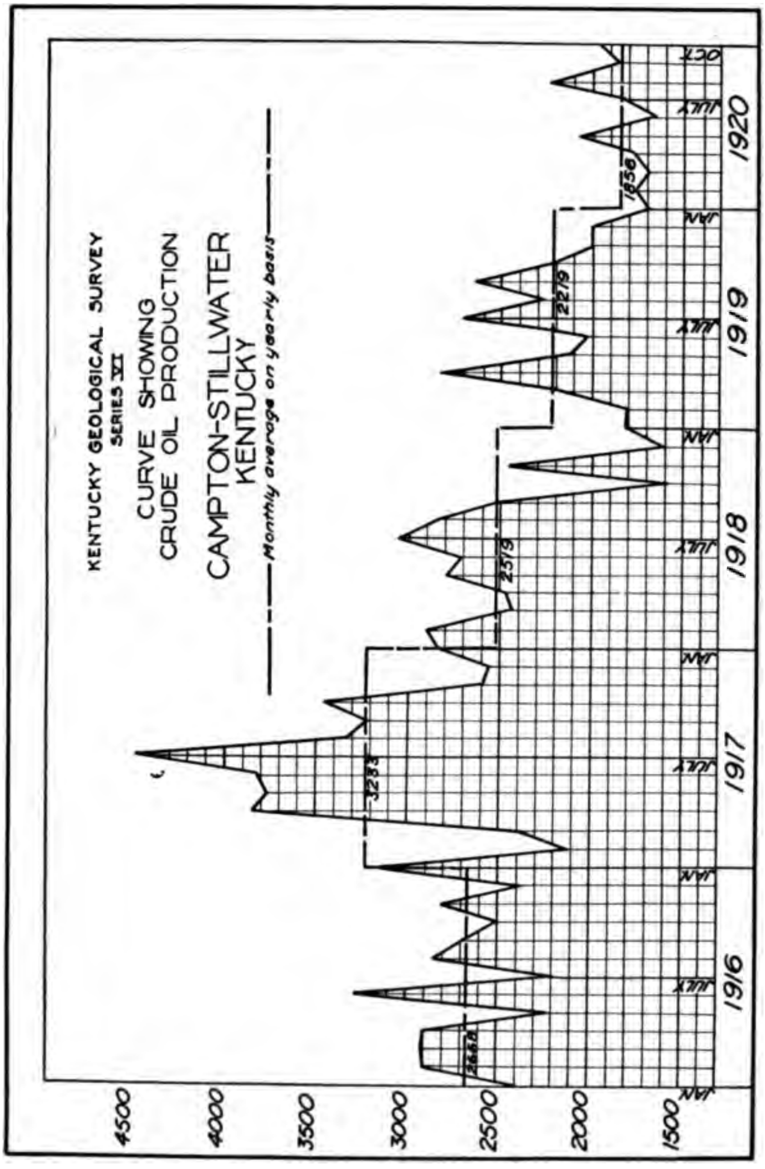
	Lincoln		McCreary		Morgan	
	Bbls.	Value.	Bbls.	Value.	Bbls.	Value.
January	736.58	$1,915.11	995.95	$2,572.00	1,147.97	$2,986.00
February	245.57	600.75	642.97	1,668.00	1,338.94	3,478.00
March	402.58	970.98	857.02	2,224.00	1,569.06	4,076.00
April	1,395.40	3,348.96	818.90	2,132.00	1,214.97	3,162.00
May	346.63	832.00	734.04	1,908.00	1,618.12	4,206.00
June	515.62	1,247.75	495.01	1,284.00	1,145.04	2,980.00
July	290.02	696.05	992.93	2,580.00	1,269.92	3,302.00
August	535.31	1,284.00	664.02	1,792.00	1,240.06	3,348.00
September	....	....	1,109.95	2,998.00	1,911.05	5,162.00
October	243.50	609.00	633.03	1,806.00	1,204.05	3,432.00
November	261.55	654.00	782.00	2,228.00	1,476.96	4,206.00
December	....	....	857.98	2,788.00	1,348.96	4,380.00
Totals	4,972.76	$12,158.60	9,583.80	$25,980.00	16,485.10	$44,718.00

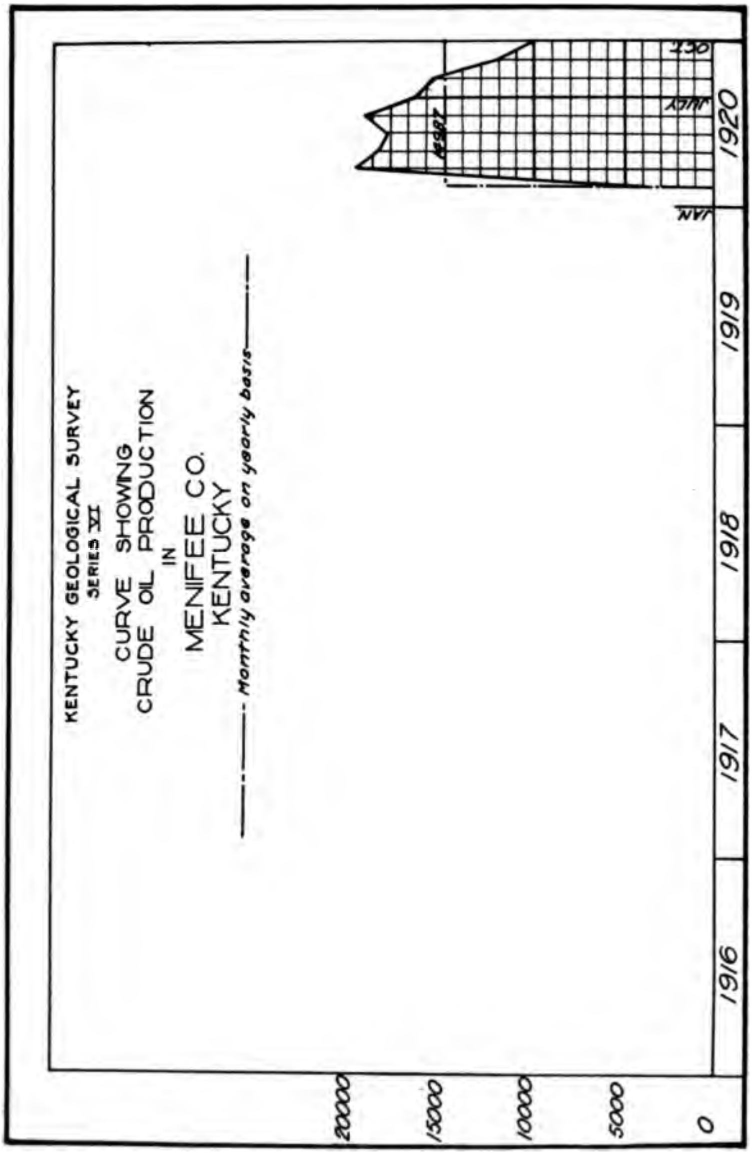
STATEMENT SHOWING PRODUCTION OF OIL IN THE STATE OF KENTUCKY BY MONTHS DURING THE YEAR 1919 IN THE FOLLOWING NAMED COUNTIES

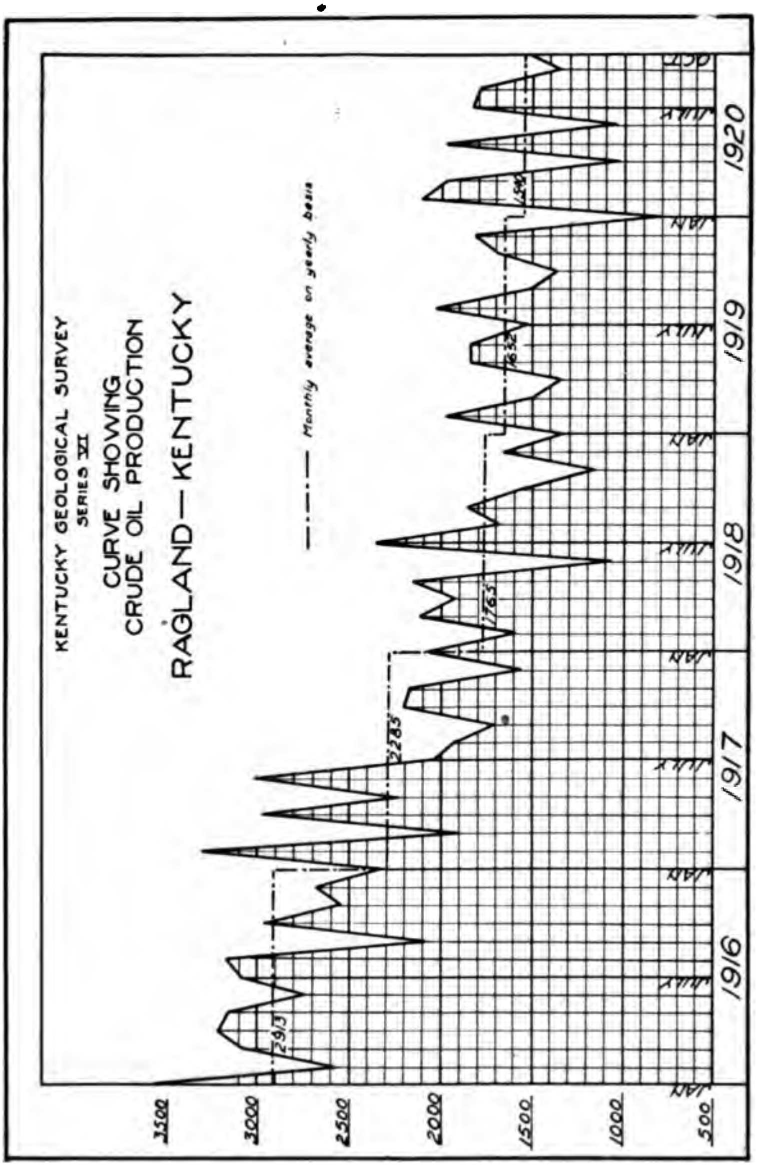
	Ohio		Powell		Warren	
	Bbls.	Value.	Bbls.	Value.	Bbls.	Value.
January	....	....	45,882.17	$119,196.15	....	....
February	191.57	$498.08	38,296.30	99,576.00	....	....
March	244.67	513.18	41,476.20	107,838.00	....	....
April	....	....	41,120.93	106,912.00	....	....
May	243.83	512.00	38,140.23	99,158.00	....	....
June	....	....	36,761.38	95,562.00	....	....
July	....	....	36,415.30	94,686.00	....	....
August	244.05	513.00	35,638.15	95,681.00	....	....
September	....	....	32,122.57	86,688.00	16,889.50	$35,819.00
October	....	....	32,868.09	93,000.00	2,277.24	5,012.00
November	....	....	26,249.23	74,738.00	1,658.94	3,870.00
December	....	....	26,442.26	84,456.00	1,754.16	4,409.00
Totals	924.12	$2,036.88	431,412.81	$1,157,491.15	22,579.84	$49,110.00

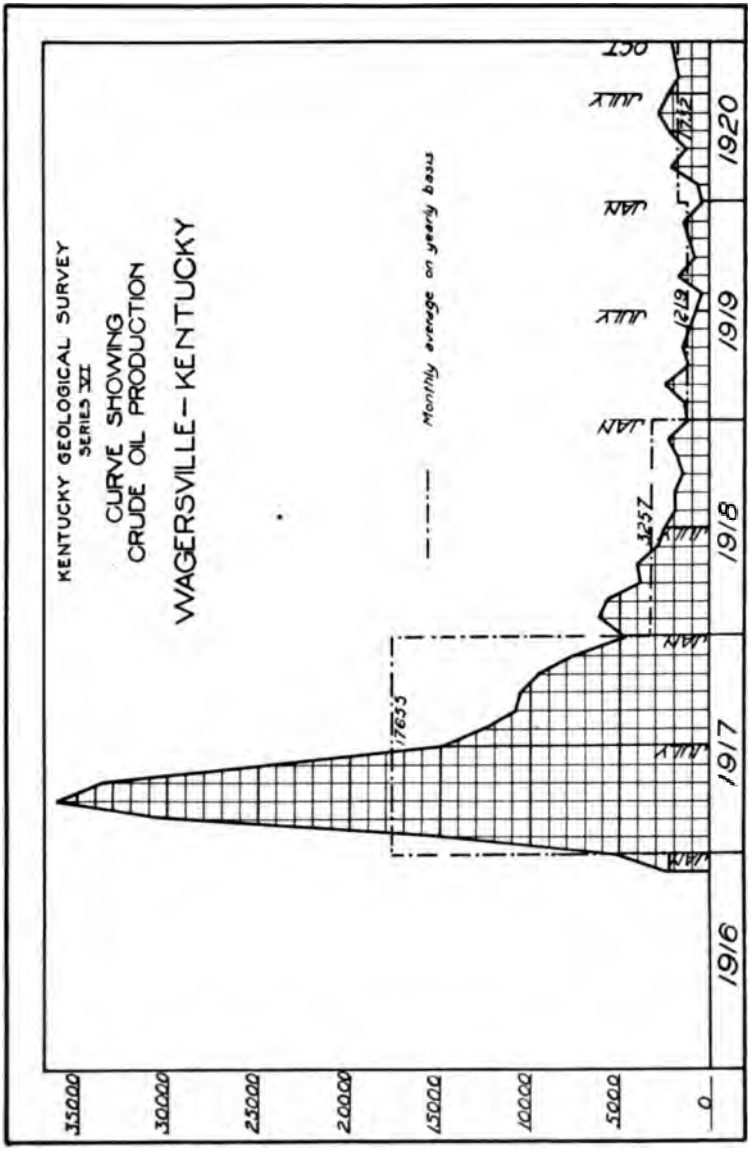
STATEMENT SHOWING PRODUCTION OF OIL IN THE STATE OF KENTUCKY BY MONTHS DURING THE YEAR 1919 IN THE FOLLOWING NAMED COUNTIES

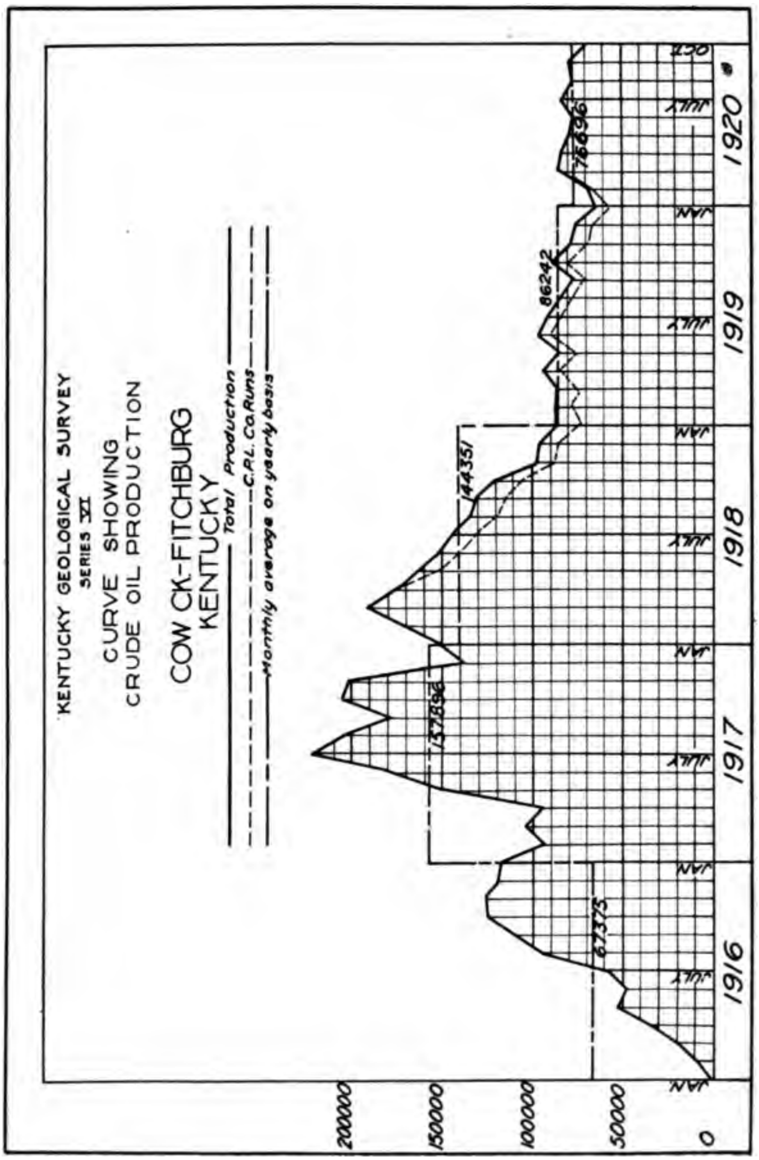
	Wayne		Whitley		Wolfe	
	Bbls.	Value.	Bbls.	Value.	Bbls.	Value.
January	13,613.95	$35,393.12	....	....	9,338.86	$24,278.00
February	12,136.41	31,557.79	150.55	$390.00	8,161.68	21,222.00
March	11,717.42	30,464.80	147.69	384.00	8,915.27	23,176.00
April	12,870.66	33,462.00	150.12	390.00	10,889.72	28,314.00
May	14,373.23	37,369.00	....	....	10,388.13	27,010.00
June	14,547.84	37,821.00	150.12	390.00	9,175.14	23,852.00
July	13,033.66	33,903.00	....	....	9,254.42	24,066.00
August	12,222.93	32,913.00	148.09	400.00	9,683.26	26,142.00
September	12,797.88	34,551.00	149.68	406.00	9,343.97	25,221.00
October	11,231.36	31,919.00	....	....	20,771.87	59,194.00
November	12,527.34	35,640.00	149.61	428.00	12,125.82	34,558.00
December	12,203.25	39,480.00	142.01	462.00	12,667.65	41,175.00
Totals	153,275.93	$414,473.71	1,187.87	$3,250.00	130,715.79	$358,208.00

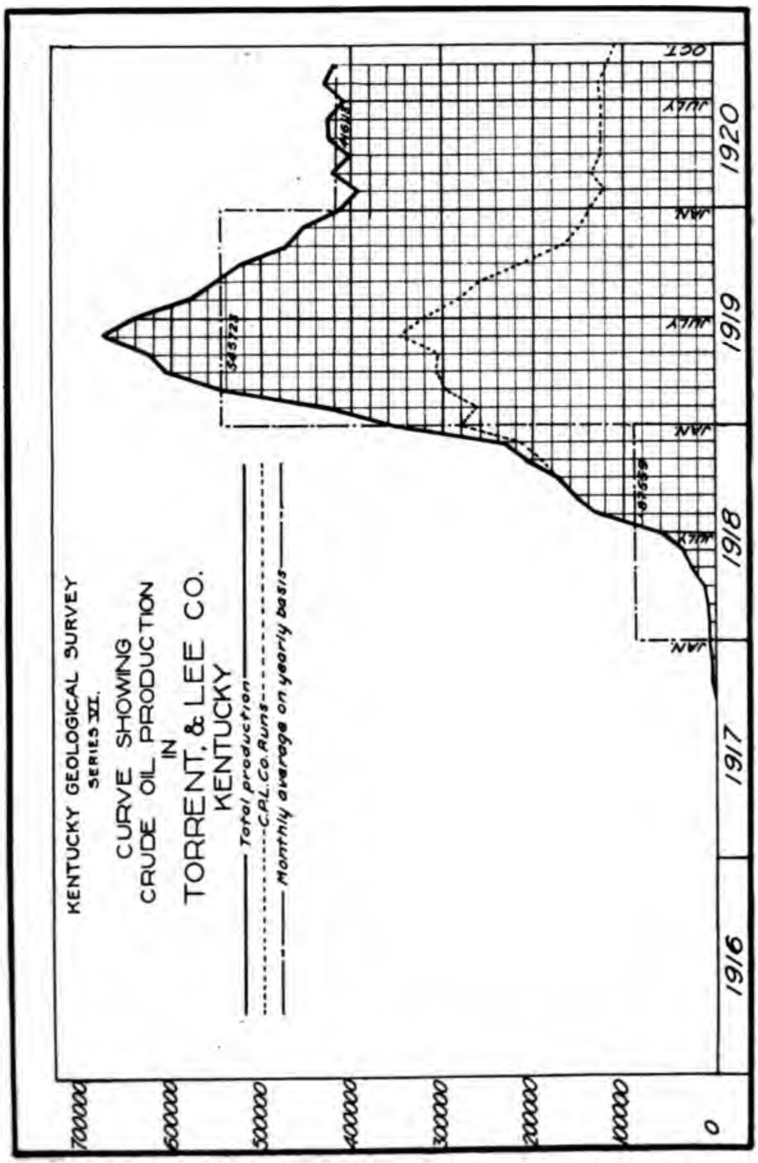

KENTUCKY GEOLOGICAL SURVEY
SERIES VI
CURVE SHOWING
CRUDE OIL PRODUCTION
CAMPTON-STILLWATER
KENTUCKY
Monthly average on yearly basis
4500
4000
3500
3000
2500
2000
1500
2668
3233
2519
2219
1856
JAN
JULY
1916
1917
1918
1919
1920
OCT

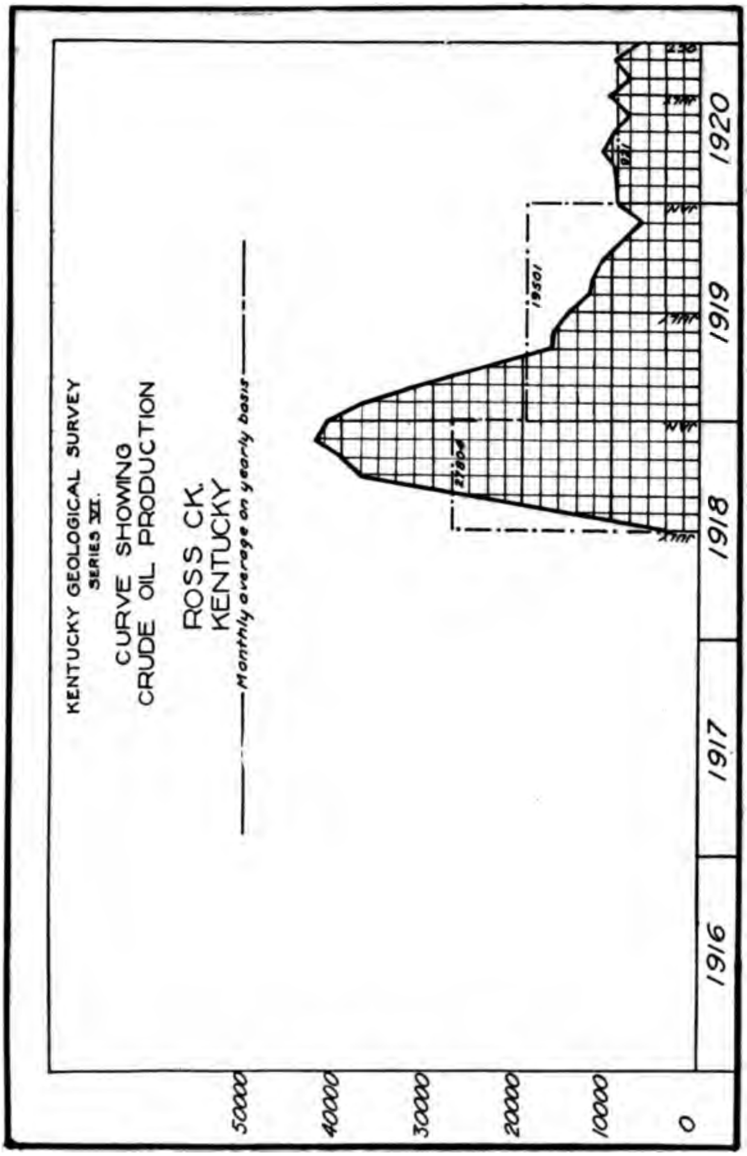

KENTUCKY GEOLOGICAL SURVEY
SERIES VI
CURVE SHOWING
CRUDE OIL PRODUCTION
IN
MENIFEE CO.
KENTUCKY
Monthly average on yearly basis
1916
1917
1918
1919
1920
JAN
JULY
OCT
0
5000
10000
15000
20000

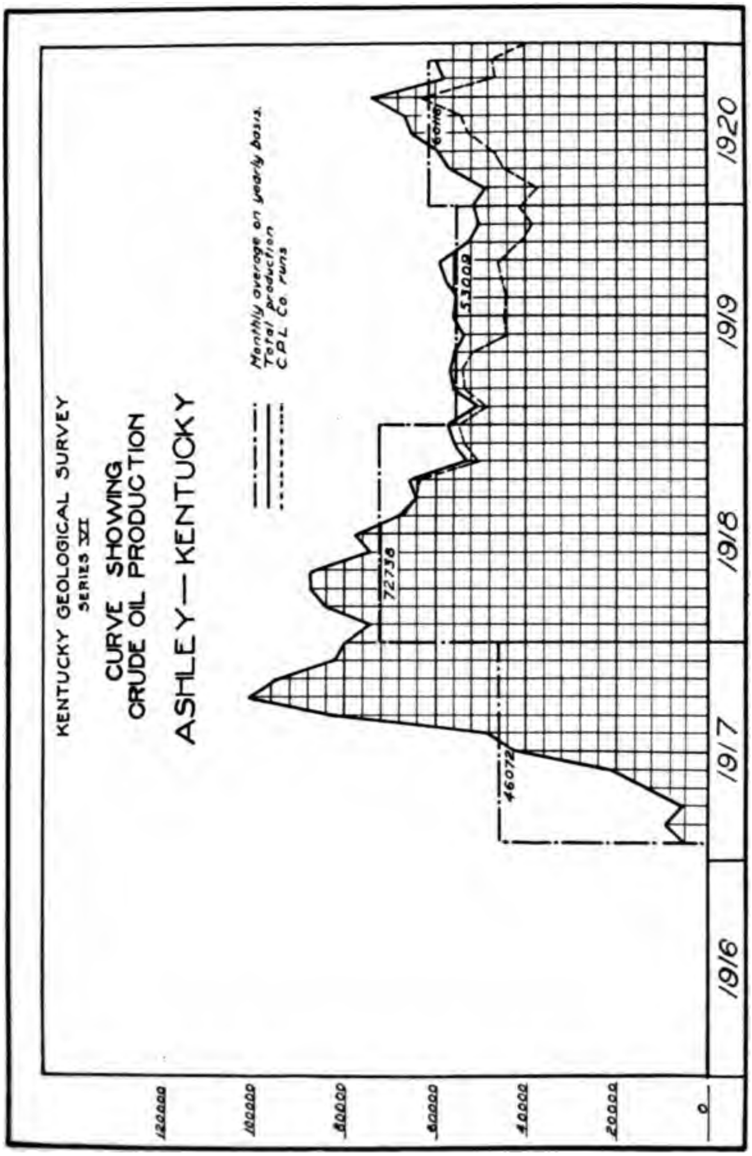

KENTUCKY GEOLOGICAL SURVEY
SERIES VI
CURVE SHOWING
CRUDE OIL PRODUCTION
RAGLAND—KENTUCKY
Monthly average on yearly basis
3500
3000
2500
2000
1500
1000
500
2913
2283
1765
1632
1590
JAN
JULY
OCT
1916
1917
1918
1919
1920


KENTUCKY GEOLOGICAL SURVEY
SERIES VI
CURVE SHOWING
CRUDE OIL PRODUCTION
WAGERSVILLE - KENTUCKY
Monthly average on yearly basis
35000
30000
25000
20000
15000
10000
5000
0
1916
1917
1918
1919
1920
JAN
JULY
OCT
17655
3257
1219
1312


KENTUCKY GEOLOGICAL SURVEY
SERIES VI
CURVE SHOWING
CRUDE OIL PRODUCTION
COW CK-FITCHBURG
KENTUCKY
Total Production
C.P.L. Co. Runs
Monthly average on yearly basis
200000
150000
100000
50000
0
67373
137896
44351
86242
76696
JAN
JULY
OCT
1916
1917
1918
1919
1920


KENTUCKY GEOLOGICAL SURVEY
SERIES VI
CURVE SHOWING
CRUDE OIL PRODUCTION
IN
TORRENT, & LEE CO.
KENTUCKY
Total production
C.P.L.Co. Runs
Monthly average on yearly basis
70000
60000
50000
40000
30000
20000
10000
0
1916
1917
JAN
JULY
1918
JAN
JULY
1919
JAN
JULY
OCT
1920


KENTUCKY GEOLOGICAL SURVEY
SERIES VI.
CURVE SHOWING
CRUDE OIL PRODUCTION
ROSS CK.
KENTUCKY
Monthly average on yearly basis
27804
19501
50000
40000
30000
20000
10000
0
1916
1917
1918
1919
1920


KENTUCKY GEOLOGICAL SURVEY
SERIES VI
CURVE SHOWING
CRUDE OIL PRODUCTION
ASHLEY—KENTUCKY
Monthly average on yearly basis.
Total production
C.P.L. Co. runs
46072
72738
53009
1916
1917
1918
1919
1920
120000
100000
80000
60000
40000
20000
0

PRODUCTION OF CRUDE PETROLEUM IN EASTERN KENTUCKY FIELDS. RUNS OF CUMBERLAND PIPE LINE CO.

Year	Month	Barrels	Total per year	Average per day	Remarks
1912	September	38,417			
	October	37,756			
	November	39,271			
	December	40,343	155,787	1,276.9	
1913	January	41,982			
	February	36,751			
	March	39,194			
	Aprl	38,794			
	May	42,716			Opening of Cannel City Pool.
	June	39,068			
	July	48,119			
	August	49,766			
	September	52,328			
	October	46,082			
	November	43,929			
	December	43,821	522,550	1,431.6	
1914	January	45,091			
	February	42,737			
	March	52,135			
	April	48,555			
	May	43,017			
	June	42,464			
	July	40,698			
	August	24,985			
	September	19,249			
	October	49,494			
	November	34,960			
	December	36,224	479,609	1,313.9	
1915	January	34,898			
	February	34,255			
	March	38,204			
	April	38,995			
	May	37,270			
	June	35,458			
	July	32,643			
	August	32,504			
	September	30,930			
	October	29,297			
	November	31,926			
	December	30,701	407,081	1,115.3	

Year	Month	Barrels	Total per year	Average per day	Remarks
1916	January	30,799			
	February	38,345			
	March	49,242			
	April	63,104			Beginning of
	May	83,348			Irvine Cow
	June	76,469			Creek Pool.
	July	85,973			
	August	125,799			Fitchburg Dist.
	September	136,659			
	October	155,147			
	November	152,652			
	December	147,213	1,144,750	3,136.3	
1917	January	150,330			
	February	136,138			
	March	171,325			
	April	162,816			
	May	236,566			
	June	254,108			Ashley Pool,
	July	308,941			Powell Co.
	August	311,302			
	September	323,897			
	October	346,381			
	November	332,898			
	December	280,938	3,015,640	8,262.0	
1918	January	262,424			
	February	285,995			
	March	316,753			
	April	306,849			
	May	298,022			
	June	280,087			Lee Co. Field.
	July	304,058			
	August	360,586			
	September	395,018			
	October	408,537			
	November	394,111			
	December	423,510	4,035,950	11,057.7	
1919	January	476,488			
	February	451,857			
	March	485,688			
	April	500,006			
	May	481,439			
	June	527,291			
	July	492,671			
	August	445,262			
	September	417,724			
	October	374,690			
	November	316,763			
	December	290,796	5,260,675	14,412.8	

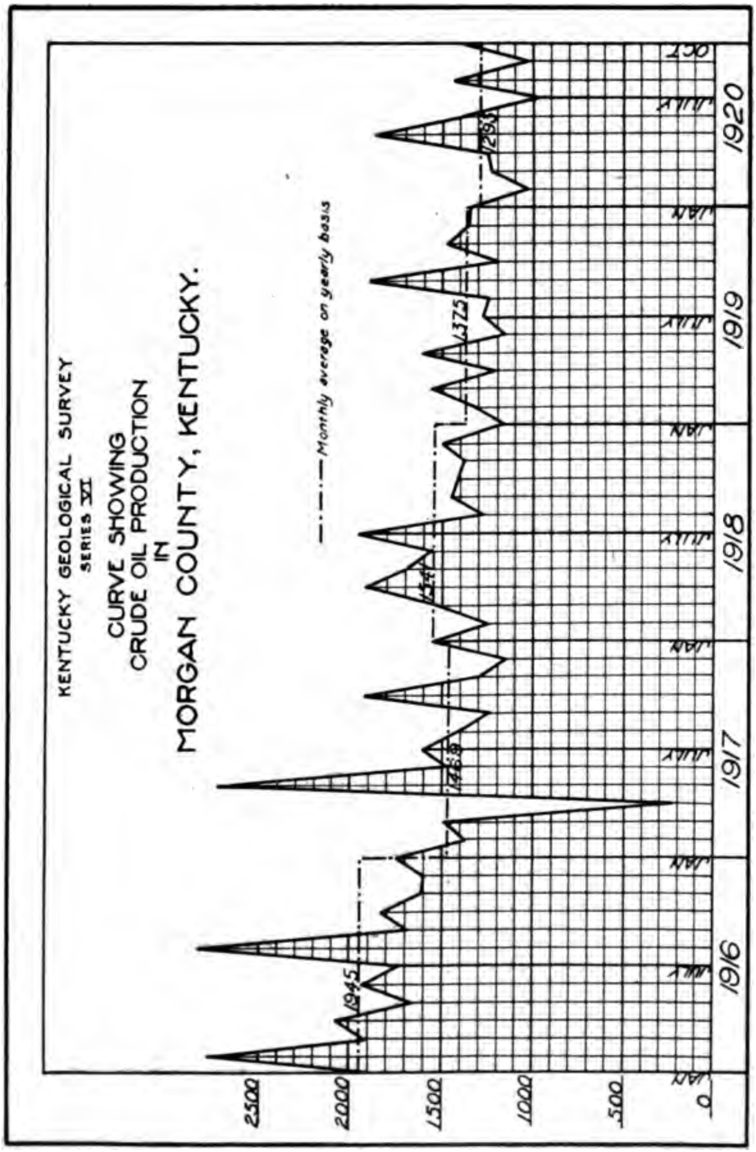
Year	Month	Barrels	Total per year	Average per day	Remarks
1920	January	279,676			
	February	270,948			
	March	333,725			
	April	327,887			
	May	326,230			Ten months
	June	326,275			daily average.
	July	344,142			
	August	322,220			
	September	320,209			
	October	292,334	3,143,646	10,307.0	
	November				
	December				

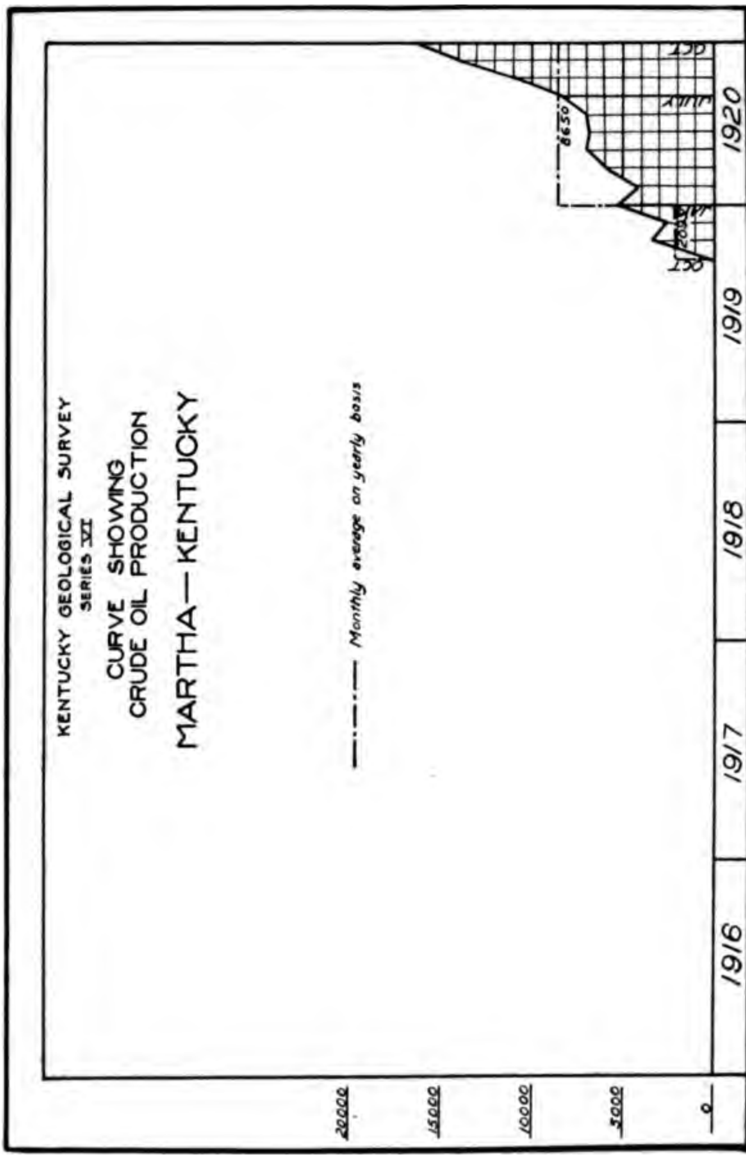
MONTHLY RUNS BY DISTRICTS—EASTERN KENTUCKY—CUMBERLAND PIPE LINE COMPANY RUNS.

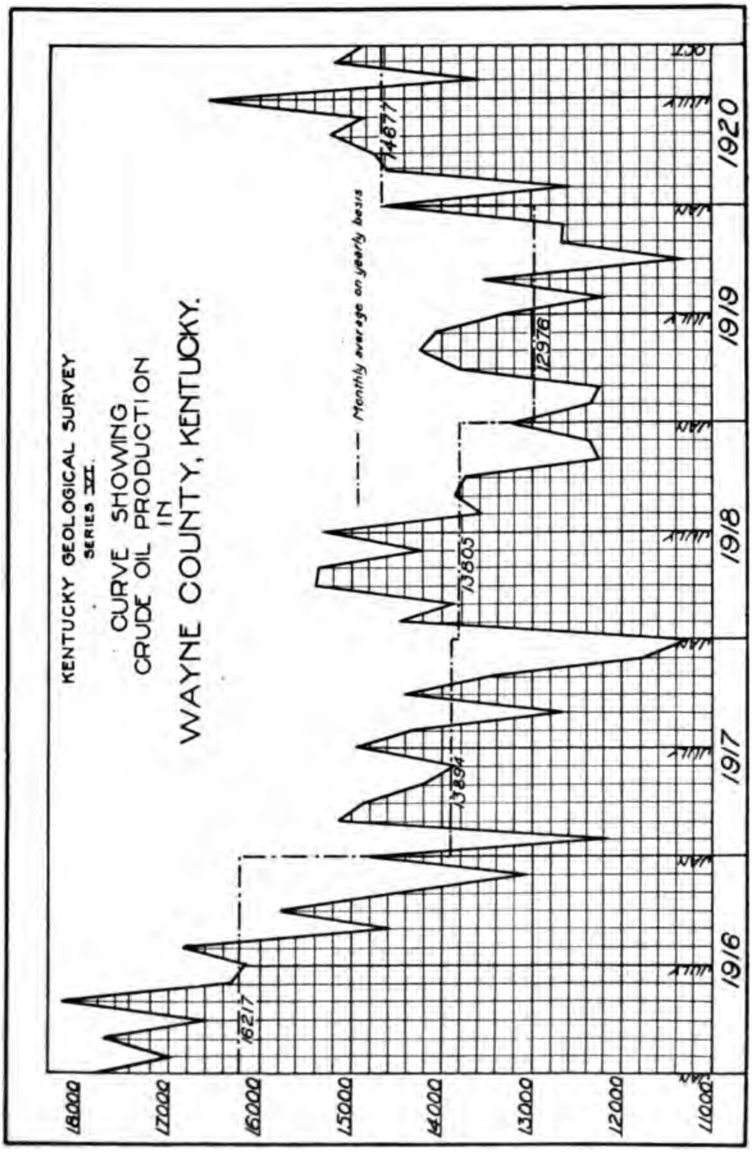
		Wayne Co.	Lawrence Co.	Morgan Co.	Cow Creek and Fitchburg	Campton, Stillwater	Beever Creek	Ragland	Wagersville	Ashley	Torrent & Lee Co.	Ross Creek	Olympia				
1916	Jan.	17,899	1,829	1,683	2,410	2,384	948	3,646									
	Feb.	17,040	2,510	2,794	9,627	2,906	904	2,564									
	March	17,758	3,333	1,908	19,405	2,925	838	3,075									
	April	16,574	2,577	2,083	34,650	2,911	1,079	3,231									
	May	18,220	3,347	1,662	53,769	2,220	964	3,166									
	June	16,299	3,239	1,927	48,138	3,281	853	2,732									
	July	16,156	3,383	1,732	58,769	2,190	644	3,099									
	Aug.	16,885	3,676	2,839	95,592	2,846	782	3,180									
	Sept.	14,535	3,190	1,677	111,795	2,692	1,908	2,071									
	Oct.	15,774	4,434	1,840	126,310	2,489	1,330	2,970									
	Nov.	14,433	2,886	1,605	127,732	2,805	649	2,540									
	Dec.	13,046	4,277	1,596	120,334	2,370	664	2,685	2,244								
1917	Jan.	14,857	3,687	1,748	118,484	3,165	849	2,320	5,220								
	Feb.	12,179	3,926	1,365	94,354	2,117	478	3,348	15,453	3,918							
	March	15,153	4,714	1,490	104,886	2,411	761	1,914	30,376	9,620							
	April	14,850	4,462	216	94,581	3,846	599	2,990	36,367	4,904							
	May	14,205	4,385	2,746	151,290	3,768	688	2,229	33,574	13,683							
	June	13,867	4,646	1,458	180,686	3,820	897	3,037	24,936	20,762							
	July	14,979	5,389	1,607	222,267	4,484	682	2,043	14,991	42,539							
	Aug.	14,302	5,936	1,396	204,960	3,343	567	1,917	12,550	48,333							
	Sept.	12,645	4,871	1,230	176,948	3,217	949	1,702	10,762	83,672							
	Oct.	14,444	5,464	1,936	205,779	3,473	480	2,211	10,514	101,762	318						
	Nov.	13,468	5,285	1,302	201,917	2,590	424	2,175	9,591	95,523	626						
	Dec.	11,776	4,289	1,132	138,599	2,558	530	1,539	7,520	82,088	3,908						
1918	Jan.	11,271	4,972	1,564	150,490	2,827	589	2,070	4,741	79,760	4,141						
	Feb.	14,470	6,322	1,235	172,991	2,911	692	1,591	6,110	74,156	4,518						
	March	13,869	6,077	1,524	191,959	2,443	458	2,136	5,663	84,747	7,877						
	April	15,396	5,924	1,934	135,409	2,470	894	1,934	3,748	87,336	11,806						
	May	15,374	6,304	1,693	152,933	2,783	831	2,160	3,969	87,467	24,518						
	June	14,197	5,906	1,562	139,528	2,717	339	1,035	2,863	74,208	37,732						
	July	15,338	6,379	1,978	132,525	3,062	533	2,373	2,471	77,983	58,434	2,982					
	Aug.	13,533	5,508	1,260	120,293	2,859	711	1,679	1,854	68,215	129,355	15,317					
	Sept.	13,852	5,325	1,445	116,111	2,507	359	1,874	1,982	64,753	158,294	28,017	496				
	Oct.	13,765	5,480	1,410	106,624	1,577	1,333	1,529	1,586	64,062	173,307	37,757	108				
	Nov.	12,235	5,126	1,378	88,298	2,474	791	1,137	1,812	50,717	189,907	39,875	360				
	Dec.	12,367	5,695	1,509	86,616	1,595	523	1,666	2,300	54,329	213,794	42,879	239				

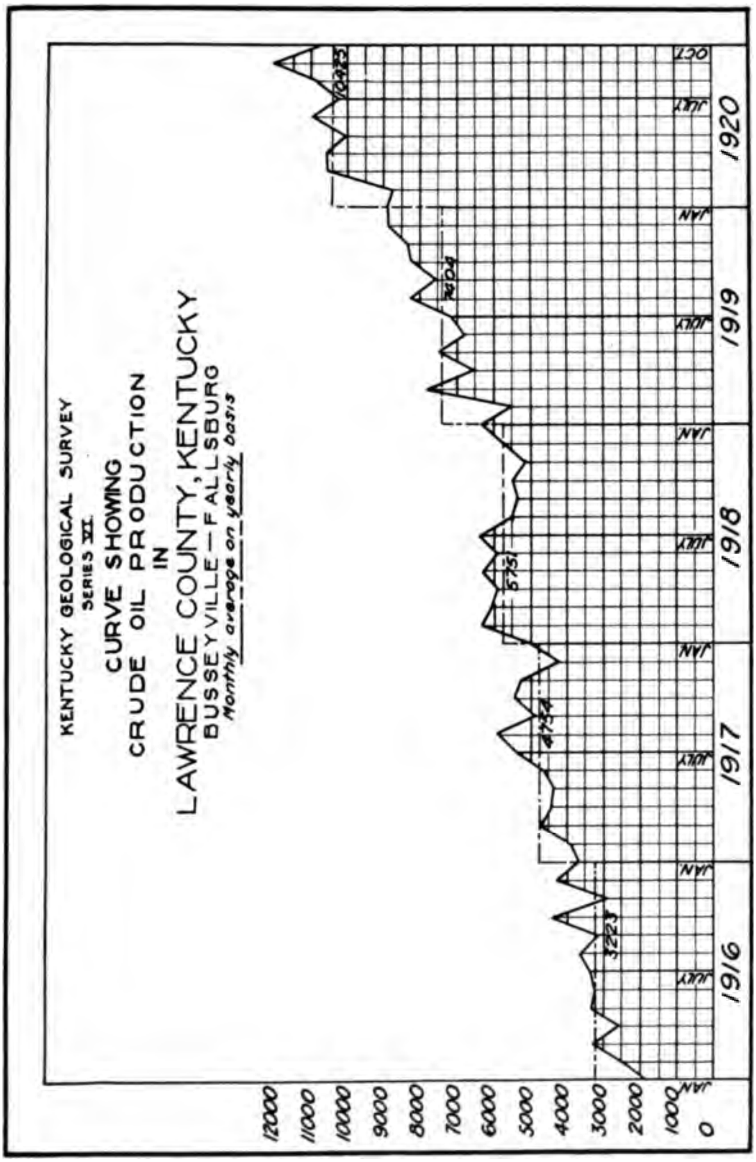
MONTHLY RUNS BY DISTRICTS—EASTERN KENTUCKY—CUMBERLAND PIPE LINE COMPANY RUNS.

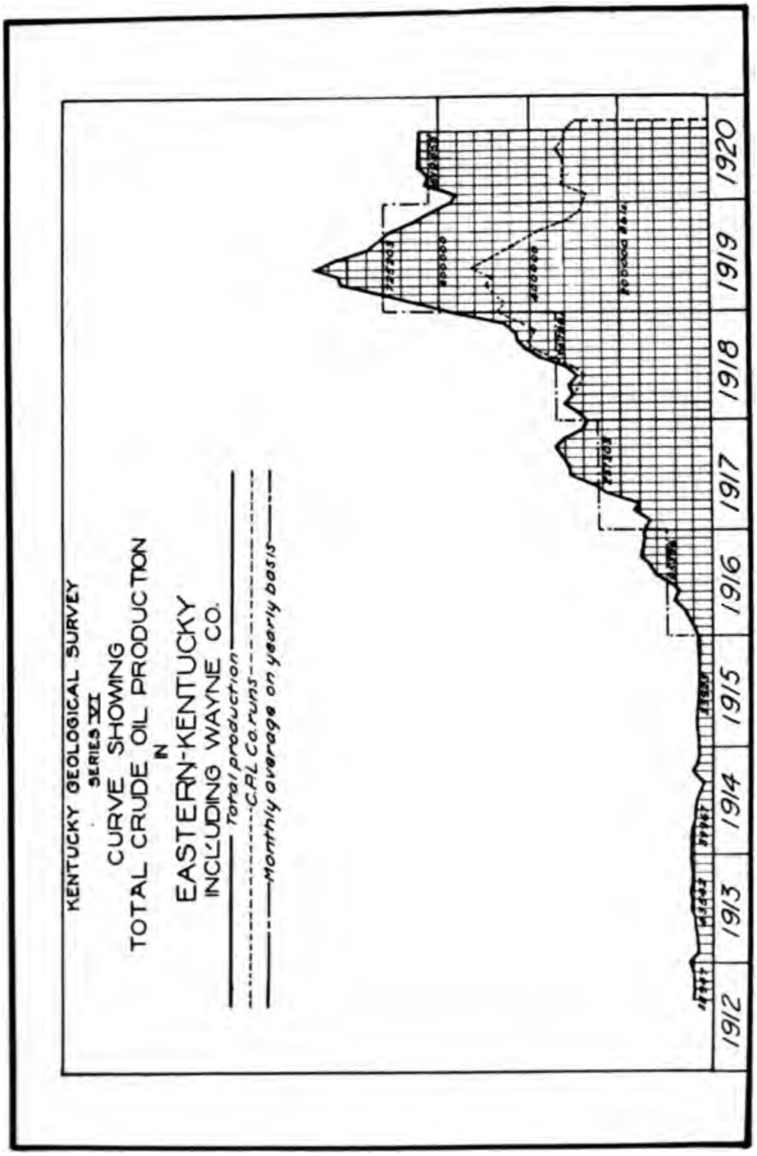
		Wayne Co.	Lawrence Co.	Morgan Co.	Cow Creek and Fitchburg	Campton, Stillwater	Beever Creek	Ragland	Wagersville	Ashley	Torrent & Lee Co.	Ross Creek	Olympia	Martha District	Menifee	McKinney	Oil Springs
1919	Jan.	13,251	6,311	1,151	73,987	1,818	609	1,324	1,201	55,055	280,356	41,427	239	....	....	....	....
	Feb.	12,356	5,493	1,339	78,633	1,799	363	1,986	1,340	48,779	261,572	38,195	....	....	....	....	....
	March	12,240	7,801	1,570	75,748	2,172	479	1,504	2,253	59,367	297,232	30,194	127	....	....	....	....
	April	13,836	6,515	1,215	84,987	2,833	475	1,339	1,186	54,119	309,342	23,958	....	....	....	....	....
	May	14,252	7,497	1,621	76,094	2,122	800	1,839	1,489	52,543	306,459	16,724	....	....	....	....	....
	June	14,083	6,788	1,144	90,030	2,019	400	1,851	1,108	44,134	349,030	16,703	....	....	....	....	....
	July	13,388	7,191	1,271	84,059	2,705	500	1,508	835	45,023	321,035	15,152	....	....	....	....	....
	Aug.	12,185	8,308	1,241	78,541	2,269	300	2,052	201	44,619	282,833	12,707	....	....	....	....	....
	Sept.	13,533	7,548	1,913	71,954	2,645	1,246	1,514	1,729	45,459	257,915	12,261	....	....	....	....	....
	Oct.	11,282	8,215	1,206	80,165	2,217	512	1,370	855	46,393	211,132	11,138	....	201	....	....	....
	Nov.	12,669	8,326	1,477	68,502	2,012	884	1,695	1,125	41,576	166,174	8,850	....	3,469	....	....	....
	Dec.	12,645	8,855	1,347	66,888	2,016	376	1,837	1,310	38,569	147,644	6,705	....	2,611	....	....	....
1920	Jan.	14,608	8,900	1,354	57,485	1,705	606	784	207	41,164	138,085	9,367	....	5,413	....	....	....
	Feb.	12,574	8,732	1,010	65,156	1,767	687	2,106	665	37,426	122,474	9,828	....	4,144	4,381	....	....
	Mar.	14,597	10,564	1,230	84,304	1,701	626	1,982	2,148	44,672	135,755	9,737	....	5,928	20,030	....	....
	April	14,748	10,581	1,250	84,131	1,766	418	1,007	1,222	47,592	127,041	11,036	....	7,011	18,657	1,426	....
	May	15,244	10,054	1,894	79,760	2,078	900	1,995	2,206	52,431	123,878	10,098	....	6,896	18,159	640	....
	June	14,871	11,596	1,385	76,633	1,655	272	1,031	2,848	54,430	123,317	7,967	....	6,978	19,473	252	3,567
	July	16,577	10,261	951	82,122	1,831	549	1,838	2,302	62,643	124,835	10,383	....	8,379	16,535	331	4,605
	Aug.	13,552	10,888	1,448	77,510	2,241	376	1,804	1,749	46,564	126,790	7,757	145	11,061	15,615	....	4,720
	Sept.	15,183	12,051	1,022	78,409	1,863	547	1,325	1,886	47,452	117,187	9,259	....	14,101	12,142	285	7,496
	Oct.	14,819	10,628	1,390	68,552	1,959	420	1,530	2,085	39,744	108,811	6,678	....	16,588	9,889	....	9,243
	Nov.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
	Dec.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....


KENTUCKY GEOLOGICAL SURVEY
SERIES VI
CURVE SHOWING
CRUDE OIL PRODUCTION
IN
MORGAN COUNTY, KENTUCKY.
Monthly average on yearly basis
1945
1375
2500
2000
1500
1000
500
0
JAN
JULY
OCT
1916
1917
1918
1919
1920


KENTUCKY GEOLOGICAL SURVEY
SERIES VI
CURVE SHOWING
CRUDE OIL PRODUCTION
MARTHA—KENTUCKY
Monthly average on yearly basis
8650
1916
1917
1918
1919
1920
0
5000
10000
15000
20000


KENTUCKY GEOLOGICAL SURVEY
SERIES VI
CURVE SHOWING
CRUDE OIL PRODUCTION
IN
WAYNE COUNTY, KENTUCKY.
Monthly average on yearly basis
18000
17000
16000
15000
14000
13000
12000
11000
16217
13894
13805
12976
14677
JAN
JULY
OCT
1916
1917
1918
1919
1920

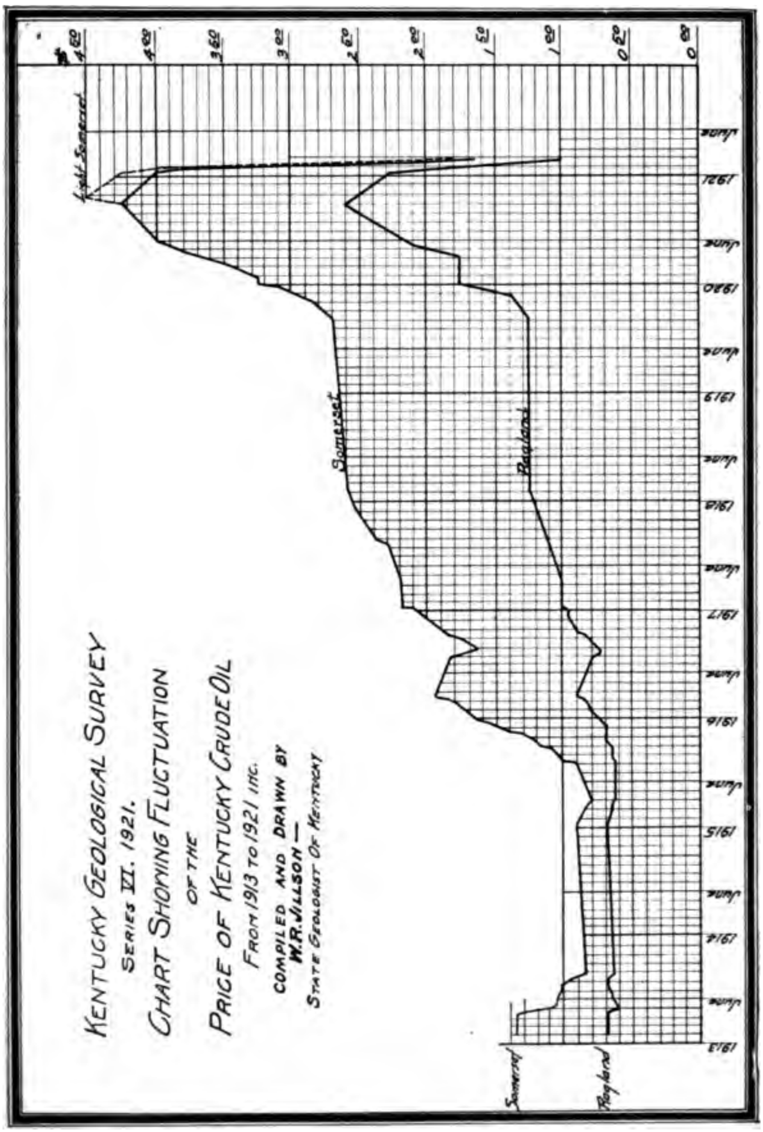

KENTUCKY GEOLOGICAL SURVEY
SERIES VI
CURVE SHOWING
CRUDE OIL PRODUCTION
IN
LAWRENCE COUNTY, KENTUCKY
BUSSEYVILLE — FALLSBURG
Monthly average on yearly basis
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
JAN
JULY
OCT
1916
1917
1918
1919
1920
3223
4734
5751
7604


KENTUCKY GEOLOGICAL SURVEY
SERIES VI
CURVE SHOWING
TOTAL CRUDE OIL PRODUCTION
IN
EASTERN-KENTUCKY
INCLUDING WAYNE CO.
Total production
C.P.L. Co. runs
Monthly average on yearly basis
1912
1913
1914
1915
1916
1917
1918
1919
1920

TOTAL MONTHLY PRODUCTION BY POOLS—EASTERN KENTUCKY (OIL RUN BY ALL AGENCIES).

		Wayne Co.	Lawrence, B'ville & Fallsurg	Morgan Co.	Cow Ck. & Fitchburg	Campton & Stillwater	Beaver Creek	Ragland	Wagers-ville	Ashley	Ross Ck.	Olympia	Martha District	Menifee County	McKinney	Oil Spgs. & Magoffin	Torrent & Big Sink-ing	Totals
1918	Jan.	11,271	4,972	1,564	150,490	2,827	589	2,070	4,741	79,760							4,141	262,425
	Feb.	14,470	6,322	1,235	172,991	2,911	692	1,591	6,110	74,156							4,518	284,996
	Mar.	13,869	6,077	1,524	191,959	2,443	458	2,136	5,663	84,747							7,877	316,753
	Apr.	15,396	5,924	1,934	175,409	2,470	894	1,934	3,748	87,336							11,806	306,851
	May	15,374	6,304	1,693	165,172	2,783	831	2,160	3,959	87,467							24,518	310,261
	June	14,197	5,905	1,562	151,767	2,717	339	1,025	2,863	74,208							37,732	292,325
	July	15,338	6,379	1,978	144,764	3,062	533	2,373	2,471	77,983	2,982						58,434	316,297
	Aug.	13,533	5,508	1,260	134,365	2,859	711	1,679	1,854	68,215	15,317						129,355	374,656
	Sept.	13,852	5,325	1,445	130,183	2,507	359	1,874	1,982	64,753	28,017	496					158,294	409,087
	Oct.	13,765	5,480	1,410	120,696	1,577	1,333	1,529	1,586	65,924	37,757	108					173,307	424,472
	Nov.	12,235	5,126	1,378	98,049	2,474	791	1,137	1,812	52,367	39,875	360					207,151	422,755
	Dec.	12,367	5,695	1,509	96,367	1,595	523	1,666	2,300	55,940	42,879	239					233,574	454,654
1919	Jan.	13,251	6,311	1,151	86,472	1,818	609	1,324	1,201	57,042	41,427	239					361,415	572,260
	Feb.	12,356	5,493	1,339	87,948	1,799	363	1,986	1,340	50,697	38,195						428,040	629,556
	Mar.	12,240	7,801	1,570	86,397	2,172	479	1,504	2,253	56,147	30,194	127					543,503	744,387
	Apr.	13,836	6,515	1,215	93,819	2,833	475	1,339	1,186	56,398	23,958						606,767	808,341
	May	14,252	7,497	1,621	85,732	2,122	800	1,839	1,489	55,802	16,724						623,565	811,443
	June	14,083	6,788	1,144	97,041	2,019	400	1,851	1,108	53,477	16,703						675,636	870,250
	July	13,388	7,191	1,271	91,466	2,705	500	1,508	835	55,862	15,152						639,721	829,519
	Aug.	12,185	8,308	1,241	84,508	2,269	300	2,052	201	54,890	12,707						578,917	757,578
	Sept.	13,533	7,548	1,913	76,976	2,645	1,246	1,514	1,729	57,921	12,261						551,774	729,060
	Oct.	11,282	8,215	1,205	89,758	2,217	512	1,370	855	58,894	11,138		201				523,020	708,667
	Nov.	12,669	8,326	1,477	78,650	2,012	884	1,695	1,125	52,645	8,850		3,469				470,593	642,395
	Dec.	12,645	8,855	1,347	76,133	2,016	376	1,837	1,310	50,342	6,705		2,611				454,720	618,897
1920	Jan.	14,608	8,900	1,354	65,139	1,705	606	784	207	51,656	9,367		5,413				410,664	570,403
	Feb.	12,574	8,732	1,010	69,626	1,767	687	2,106	665	49,049	9,828		4,144	4,381			394,788	559,357
	Mar.	14,597	10,564	1,230	85,074	1,701	626	1,982	2,148	56,787	9,737		5,928	20,030			421,876	631,280
	Apr.	14,748	10,581	1,250	84,131	1,766	418	1,007	1,222	59,585	11,036		7,011	18,657	1,426		403,189	616,027
	May	15,244	10,054	1,894	79,760	2,078	900	1,995	2,206	65,480	10,098		6,896	18,159	640		426,356	641,760
	June	14,871	11,596	1,385	76,633	1,655	272	1,031	2,848	66,927	7,967		6,978	19,473	252	3,567	427,041	642,496
	July	16,577	10,261	951	82,122	1,831	549	1,838	2,302	74,460	10,383		8,379	16,535	331	4,605	409,127	640,251
	Aug.	13,552	10,888	1,448	77,510	2,241	376	1,804	1,749	57,656	7,757	145	11,061	15,615		4,720	431,534	638,056
	Sept.	15,183	12,051	1,022	78,409	1,863	547	1,325	1,886	59,442	9,259		14,101	12,142	285	7,496	420,441	635,452
	Oct.	14,819	10,628	1,390	68,552	1,959	420	1,530	2,085		6,678		16,588	9,889		9,243		
	Nov.																	
	Dec.																	

Note: Previous to 1918 the C. P. L. Co. transported all of the oil listed in districts.


KENTUCKY GEOLOGICAL SURVEY
SERIES VI. 1921.
CHART SHOWING FLUCTUATION
OF THE
PRICE OF KENTUCKY CRUDE OIL
FROM 1913 TO 1921 INC.
COMPILED AND DRAWN BY
W.R. JILLSON —
STATE GEOLOGIST OF KENTUCKY
Somerset
Ragland
Light Somerset
1913
1914
1915
1916
1917
1918
1919
1920
1921

KENTUCKY CRUDE OIL PRICES

The recent tremendous slashing of the prices paid by the principal oil purchasing agencies for Kentucky crude has caused much interest in the fluctuations as a reflection of the industrial activity of the country. Herewith are presented the Somerset and Ragland prices from February 5, 1913, to February 26, 1921, a period of eight years. The lowest price is $.85, on August 20, 1913; the highest $4.50, on October 11, 1920.

1913	Somerset	Ragland
February 5	$1.35	$.70
April 17	1.35	.70
April 20	1.30	.70
April 22	1.25	.65
April 27	1.20	.65
April 30	1.10	.60
May 11	1.05	.65
June 1	1.05	.65
July 15	1.02	.70
July 28	1.00	.70
August 8	.95	.70
August 12	.90	.67
August 17	.87	.67
August 20	.85	.65
1915		
January 4	.90	.70
March 15	.85	.65
March 20	.83	.65
April 3	.80	.63
August 13	.90	.63
August 17	1.00	.65
August 24	1.00	.65
September 13	1.03	.65
September 27	1.08	.65
September 27	1.08	.65
October 7	1.17	.65
October 27	1.22	.65
November 5	1.27	.68
November 15	1.32	.70
November 18	1.42	.70
December 3	1.50	.70
December 17	1.55	.72
December 30	1.63	.75
1916		
January 28	1.73	.80
February 21	1.78	.82
March 6	1.85	.85
March 17	1.95	.90
July 29	1.85	.80
August 3	1.75	.75
August 10	1.70	.75

1916—Cont'd	Somerset	Ragland
August 15	1.65	.75
September 28	1.75	.80
October 10	1.85	.85
October 20	1.95	.90
October 31	1.90	.90
December 5	2.00	.95
December 29	2.05	.95
1917		
January 5	2.10	.97
January 9	2.18	1.00
April 17	2.20	1.00
August 13	2.30	1.10
August 20	2.40	1.10
December 4	2.55	1.20
1918		
February 8	2.60	1.25
1919		
September 2	2.70	1.25
November 7	2.85	1.35
December 22	3.10	1.60
December 31	3.25	1.75

1920	Somerset	Ragland	Light Somerset
January 26	$3.25	$1.75	....
March 1	3.50	1.75	....
April 2	3.75	1.75	....
May 10	4.00	2.10	....
September 23	4.25	2.60	....
October 11	......	......	$4.50
1921			
January 8	4.00	2.25	4.25
January 21	3.75	2.00	4.00
January 31	3.50	1.75	3.75
February 4	*2.75	*1.50	3.00
February 11	2.25	1.25	2.50
February 15	2.00	1.15	2.25
February 21	1.75	1.00	2.00
February 26	1.65	1.00	1.80

*Price effective at 11:35 a. m.

Manuscript completed Mar. 1, 1921.

V.

THE VALUE AND DIRECTION OF STATE GEOLOGICAL SURVEYS*

The fundamental importance of State Geological Surveys from a scientific as well as economic standpoint in the development of our mineral resources has in this day become widely recognized rather than doubted. The time was, however, when good people generally had little conception of the kind of activities or the value of State Geological investigations. This change in public opinion has been a very natural one in which the first stimulus was the sound application of the geological principles enunciated by the older geologists of this country. Co-ordinated with the awakening of the public interest there has been established in the United States a great body of geologic literature and thought, the potential value of which, in the exploitation of our natural resources, cannot be over estimated.

Any discussion of the value or organization of State Geological Surveys would be incomplete without some introductory statement concerning their historical development. Geological information has always been advanced either by individuals working separately, or in groups, and today geological literature may be divided on this basis into two classes, of (1) that of the independent research student, and (2) that of the group of research workers who collaborate in the results of their observations and philosophies. The work of the individual in many cases is privately directed, and for many years the University teacher has been the foremost in this field of sporadic, uncorrelated investigations. The work of groups is generally allowable of more co-ordination, and frequently it is so organized and adapted as to take up in local and systematic sequence a large group of related problems. It is not only in the surveys of the States, but also in the federal Geological Survey, that the work of groups developing the feature of co-operation as between individual workers is most strongly developed. It is

*This paper presented at the University of Cincinnati, May 5, 1920.

also a fact that these reports, which are based on the investigation of groups generally, show the best and most reliable geological interpretations. This is not invariably the case, but is of such frequent occurrence as to cause geologists, generally, to value the co-operation of their fellows, both in the field and in the review of their manuscript.

Origin of Geological Surveys.

During its infancy the now well established science of geology found its advance principally through the individual resources of private parties. When it became apparent that individuals were not going to be able to cary the work forward rapidly or thoroughly enough to meet the demand of the growth of this country, the aid of the general public was solicited; and the early geologists, seeking such public aid, came to have an understanding of political mechanisms and valuations. In the United States the first Geological Survey was established in North Carolina in 1823, when the General Assembly of that state authorized its Board of Agriculture to pay the expenses attached to "Geological Excursions" for a certain number of years. Prof. Denison Olmstead, of the State University of North Carolina, was appointed to direct the work. In 1824, South Carolina, with Lardner Vanuxem as its State Geologist, began its work. In 1830 Edward Hitchcock undertook the work for Massachusetts. This was in reality the first real State Geological Survey, as the organization of the Carolinas were small and rather unimportant.

Dr.Gerard Troost began the state examinations for Tennessee in 1831, and in 1833 Jules T. Ducatel undertook the investigation in Maryland. As an assistant he had J. T. Alexander, who had the title of State Topographical Engineer, and has been credited with producing the first topographical maps in this country. In 1835 the Virginia Geological Survey was inaugurated, and under the directorate of W. B. Rogers. In the same year, H. D. Rogers took charge of the New Jersey Survey, and J. G. Percival and Charles U. Sheppard, as Geologists in charge, began the work in Connecticut. In 1836, the year following, there was organized in the state of New York the Geo-

logical Survey of the same name, which was destined to be the peer of all others in the east. W. W. Mather, Lardner Vanuxem Thomas A. Conrad, Ebenezer Emmons and James Hall divided the state up between them. They had the idea in mind, which was then commonly prevalent, that each would carry a certain area, which, when finished within a specified length of time, generally a year or two, would complete the Geological Survey of that commonwealth. The complete fallacy of this conception of State Geological work did not make itself apparent for many years, and as late as the latter part of the 19th century it was commonly believed by many that a single investigation of any given area would be sufficient for all time. In the same year the Pennsylvania Geological Survey secured the services of H. D. Rogers from the neighboring state of New Jersey, and Georgia started its work with John R. Cotting as its State Geologist. These years were indeed a time of awakening in internal improvements throughout the eastern states, and so we are not surprised to find Maine, farthest removed to the north-east, undertaking its original work with Charles F. Jackson as director of its geological investigations.

The organization of State Geological Surveys then followed in rapid succession. Delaware, Ohio and Michigan in 1837; Kentucky, under W. W. Mather, in 1838; Rhode Island in 1839; New Hampshire in 1840; Vermont in 1845; Alabama in 1847; Mississippi in 1850; Illinois in 1851; Florida and Wisconsin in 1853; Iowa in 1855; Arkansas in 1857; Texas in 1858; California in 1860. Thus through the process of gradual and substantial growth there came to be established in practically all of the states of the Union important geological investigating bodies called Surveys, sustained by funds dedicated to the principle of assisting in the development of a scientific understanding of the earth's crust, and its mineral wealth.

The most celebrated geologists of this day were Hall, Hitchcock, Owen, Mathers, Vanuxem, Emmons, Conrad and the Rogers brothers. They were assisted in their labors by a larger group of younger men less conspicuous at that time, but who through sound training under the capable tutelage of these older men, have since become recogniged geologists of national and international reputation.

THE U. S. GEOLOGICAL SURVEY.

Prior to the time of the Civil War, the United States Government had done very little to assist geological investigation. A few rapid reconniassance surveys had been made of very wide areas, such as those undertaken and completed by David Dale Owen in the Upper Mississippi valley, in the present states of Iowa, Illinois, Nebraska, Wisconsin and Minnesota, for the United States Land Office and the Treasury Department during the years of 1839 and 1851. The War Department enlisting the services of a number of distinguished geologists, including Newberry, Hall, Marcou, Blake and Conrad, in the years 1853 and 1855, made what has become known as the Pacific Railroad Surveys. Closely attending the resumption of peace time activities following the closure of the Civil War, forward looking governmental officials saw the necessity of securing broadly distributed, yet accurate information concerning the topography, resuorces and climatology of that great western country which we know as the Rocky Mountain and Pacific coast belt.

In following out this idea, four exploring organizations were dispatched to the westward under the direction of the War Department. These were the King, Wheeler, Hayden and the Powell Surveys. They were very largely Geological Surveys and were executed with such diligence and dispatch that their value became at once self-apparent, and resulted in their combination of the year 1879, under the title of the United States Geological Survey. Clarence King was made the first director, and further investigations of the western country were immediately undertaken. As the years passed, the investigations of the United States Geological Survey became broadened so as to cover the older states to the east, as well as the newer states of the west, so that today its territorial scope is only limited by the boundaries of the Union. It is, as a matter of fact, now conducting correlated investigations quite generally on some plan of co-operative finance in almost every state and territory.

ECONOMIC AND SCIENTIFIC SURVEYS.

A consideration of the economic importance of State Geological Surveys is worth while, since it is due to this feature

that they owe their first inception, early maintenance, and present-day firm establishment. It has been said that the principal office of a Geological Survey is to place geological information on maps so that it may be useful for other investigating parties, whether trained geologists or not. Such, however, is only a partial consideration of the work which a Survey may do. Many results obtained from field investigations are not readily applicable to any kind of map representation. Typical of these are scientific descriptions of fossils, and the practical descriptions of the openings and development of mines, and the gratuitous and freely given consulting advice of the State Geologist. Such things obviously would be lost were they not to be recorded in printed form in a systematic sequence. Such a collection of data and the allied observations and philosophies has come to be known as a geological report. It may be a broad and general outline covering a certain area, or it may be detailed and specific for the same area. In either case, it supplements and increases the value many fold of the geological map of the same area.

Investigations of the geology of any state naturally divide themselves into two groups: The purely scientific and the purely economic. All economic reports find their geologic basis on some scientific report, or reports, but the converse is not true. In the early development of the Geological Surveys of this country it was very common to issue reports which were either purely scientific or purely economic. Today, and indeed for the past two decades. it has come to be recognized practice to use all pertinent scientific data in preparing an economic report, sensing that each lends strength to the other. In the light of this full appreciation of the proper organization of geological investigations, the more recent and more valuable reports of all State Geological Surveys show some systematic combination of these two features.

The early reports prepared by the first geologists of this country were not ordinarily written so as to be useful to the layman Their descriptions, though accurate, were frequently tiresome and unreadable, and they tended to discourage the interest of the general public rather than to fascinate. Through the growth of a wide spread demand, there has been in these

latter years an evident and wholesome change for the better, with the result that now many geological reports, no less accurate than before, are written with more literary-commanding style. This new virtue has been steadfastly coupled with a consistent appreciation of the practical value of the report of the various mining and manufacturing industries of the country. As a result the office of every active State Geological Survey is in this day besieged with many thousands of communications requesting definite geological information concerning various areas within the state, and their industrial or mining development. So it has come to be a large part of the official routine of the up-to-date State Geological Survey to assist in the convervative exploitation of the natural and mineral resources of the Commonwealth it serves. Among the economic reports of this Appalachain region, those dealing with coal, petroleum, natural gas, oil shale, asphalt rock, fluorspar, lead, zinc, calcite, barite, phosphate, mica, glass sands, abrasives, the precious metals, iron and steel are most important.

Geological Survey Organization.

The organization of any Geological Survey is a task that is individual. It is individual to the Commonwealth in which it is organized because of the pecularity of its own geology and mineral resources. It is also individual insofar as the knowledge of its director goes, for manifestly the direction of a Geological Survey can be no broader or better constructed than the geological understanding of its director will allow. A Geological Survey is individual since it is entirely dependent upon funds provided for its maintenance by the State Legislature. These due to political whimsicalities may be adequate or even large for a year or two and then practically nothing for a period of years to follow. The legislative mind may be largely influenced by the capabilities and personality of the State Geologist. The successful State Geologist should then be a man of fundamental and constructive training who has in mind the general geological problems of his state and the disposition and ability to secure the funds necessary to their solution.

Geological problems ripe for investigation will fall into the various classes referred to above and each will vie with the other for first consideration. Maintenance funds are always limited, whether they be large or small, and great perplexity always attends their equitable apportionment to the varying importance of each separate office detail or field investigation. It is now recognized that topographic maps of the scale of 1 to 62,500 should precede all detailed investigations, though the scale 1 to 125,000 may be satisfactorily used for reconnaisance purposes. In many states the absence of such topographic maps is a serious factor retarding the proper direction and effective organization of the field work. The geological friendship, acquaintance, and appreciation, if the terms may be so used, of the Director of any State Geological Survey are constantly being put to the test in making selections of the men best qualified to map or report on separate areas or mineral resource industries.

This a day of specialists. Specialists stand in the front rank in all professions, and not the least of these is geology. Practically every geologist, though he has a fine background of general geological training, will have picked out for himself by the time he reaches his 30th milestone, some field of specialization. . Many men who are specialists, however, combine with their line of principal endeavor some parallel investigation. The stratigrapher, for instance, will generally turn himself to oil investigations and the petrologist will interest himself in the mining of metals. In bringing new men into a state to investigate any separate field, all of these features of the geologist's training and adaptability must be considered if the best results are to be obtained.

Frequently localized areas of some special mineral resource overlap state boundaries, and a man who has received considerable training and education in working out the geology of an area in one state may be brought across the boundary into another with very great advantage in the saving of time, and in the essential understanding of the geology of the second area. This is obviously the thing to do when possible since the geologist thus secured is an experienced man to start the work. The greatest disadvantage in the selection of new field geologists is found in their universal lack of familiarity or acquaintance

with the type of topography and geology in the prospective field. And this is a handicap which every Geological Survey faces when it engages a young, or a new geologist. A university graduate is for this reason of very little importance to any Survey as a geologist during his first year. He is plainly of less value to those Surveys far removed from his place of training than he is to those close at hand. However, if the young university geologist has combined an engineering training in mapping, with his geological work, his services should be worth a premium as soon as he graduates.

It would be unfair to close any remark concerning the work on State Geological Surveys without some statement as to present economic conditions within the Surveys themselves. I mean by this the living conditions, which determine the *esprit de corps* of the survey groups. During the past few years very few, if any, state oppropriations for purely geological investigations have been increased, and as a result it has been impossible to increase salaries in proportion with the increased living cost. Expenses for maintenance of all Surveys have doubled and trebled, and these have had to be met. The result has been that the work on those Surveys where the appropriation has not been elastic, has had to be cut down in area in order to allow for this greater cost. The growth of various economic industries, including oil, and coal mining, has on the other hand opened an increasingly large field for geological investigation and employment. Salaries and other general working conditions have been made very attractive in the corporate investigations, and many men have been drawn away from their work on State and Federal Geological Surveys to take up this sort of geological work. The result has been that a certain pauperage of geological talent has stalked unopposed into the professional ranks or state employed geologists, and the end is not yet in sight. What the State Geological Surveys of the future will be in personnel and effectiveness cannot now be foreseen, though it must be recognized that the tendency is toward the gradual impoverishment of their best geological talent and initiative.

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VI.

RIVER AND FOREST TRAILS IN WESTERN KENTUCKY.*

Summer is here and with it the out of doors privilege of the world. Down through the dawn-kissed meadows a riot of red clover is calling the bee. In yonder old-fashioned garden dew-studded morning glories like bits of blue sky lie sprinkled along the hedge flanked by rows of bell-faced hollyhocks, red, purple and white—a paradise for humming birds. Up from their nightly haunts by the river whole flocks of rollicking chattering grackle are winging their way under the clear morning sky to the open country beyond, saying as they go, "Come on! Come on!"

Where is the man who knows Kentucky as do these dusky feathered folk? What native son can tell the tale of fields of yellow grain, of mineral wealth, of natural beauty in Mountain, Blue Grass and Pennyrile one-half so well? None but he who has roamed with lightsome heart through the countless hills and valleys, who has left at dawn the new made friend, and found again ere nightfall another kindly and hospitable face.

He it is who has felt the strong pulse of Kentucky beat, when on the broad and level pike he has stopped to ask his way of ploughboy or of housewife. His was the joy when down some shady, half-forgotten lane he suddenly came upon groups of laughing, barefooted school children exhaling in their play the breath of a great tomorrow. His happiness has been the glint of the new moon in the river, the distant baying of hounds and flaring of torches in the 'possum hunt, and the quiet atmosphere of quaint little single street villages nestling among the obscure hills. These are the kind of things he has come to know and to love. Their charm is individual and quite apart from that of the larger towns with their glittering printed names, their tawdry crowds and other commonplace distinctions.

For he who would see for himself the natural wealth and beauty of his native state, there is an excellent route from Louisville along the south shore of the Ohio river into western-most Kentucky This trip takes one through Hardinsburg, Owens-

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boro, Henderson, Uniontown, Marion, Princeton, Eddyville, across the Cumberland and Tennessee rivers, and into the "Purchase" at Benton. Thence the route is south to Murray, north-west to Mayfield, south-west again to Fulton and Hickman on the Mississippi river. Here the road swings northward to Clinton, Bardwell, Wickliffe and back eastward to Paducah. During the summer this trip may be made in an inexpensive automobile in five days with good hotel accommodations and less inconveniences of travel than many might expect. The route is a good one for several reasons, the principal one of which is that few take it. For this reason the road is fairly clear of traffic, allowing one to see the open country and breathe those fresh and natural fragrances which are not to be found anywhere else in all the world.

Every vista of Kentucky along this trail bordering the south shore of the Ohio river is new and delightful. From Louisville to West Point it leads through the Ohio bottoms over an excellent road built of Kentucky Rock Asphalt, a mineral product now being mined on a large scale in Edmonson county. Just before reaching West Point one crosses on a new steel bridge the famous Salt river near its junction with the Ohio. After leaving the town the road runs close to the river for a little, then turns abruptly to the south, and one is offered his choice of two roads. He may elect the new cement U. S. Army road leading directly to Camp Knox, or the older Dripping Springs macadam road, now somewhat rough. Both climb up over Muldraugh's hill, which is the great escarpment of Mississippian limestone so well known to the residents of Louisville.

Once on the top, if he has taken the Dripping Springs road, he will proceed over an undulating table-land through Vine Grove to Camp Knox. Here besides the interests which attach to the camp, he will note the abundance of apple orchards and remember that Hardin county is celebrated for its fruit growing and dairying. At the edge of the government military reservation the trail turns abruptly to the west, and passing through Otter creek in Meade county and into upper Big Spring valley, the tourist finds himself well on the way to Hardinsburg. The road in western Meade and north-eastern Breckinridge county, in the vicinity of Bewleyville and Sinking creek, is a little rough

but the country is beautiful. Broad farms well taken care of are on every side, for Breckinridge and Meade counties both produce large amounts of corn, hay and wheat.

From Hardinsburg westward the road improves a little. At the edge of Hancock county one leaves the lower lying Mississippian limestones and climbs up over the second great escarpment—that of the lower sandstones and conglomerates of the Pottsville formations. These rocks are the first of the Coal Measures to be seen. From now on until he nears Marion, in Crittenden county the traveler will be in the western Kentucky coal field. In the vicinity of Patesville and Pellville, the road winds down into the upper forks of Blackford creek, and one is reminded strongly of some parts of eastern Kentucky by the little narrow valleys, and the small but well farmed bottom lands in them. In this section the roads are part of the time in the creeks, and the native homes are there, too, just a little removed above high water.

The road from Knottsville into Owensboro is fairly good and one which will not easily be mistaken. Davies has much mineral and agricultural wealth. It has long been a producer of coal, its commercial production or 1918 amounting to 86,552 tons, valued at $191,554.00, which was considerably exceeded in 1919.

In this country there is some little prospecting going forward for oil and gas. It is rumored that crude oil has been discovered in at least one or two wells, which it is thought will eventually lead to commercial production in those sections. In 1918 Davies county produced 3,200,000 bushels of corn and 300,000 bushels of wheat, and had much less waste land than any adjoining county.

Most of the good roads around about Owensboro are made from Ohio River gravels. One wonders, as he slips along between fields yellow with wheat and oats, or green with corn and clover on the road to Henderson, why it is that these same gravels are not used more extensively in this part of the State. The only fault which can be found with them is that they are smooth and therefore roll easily. These Ohio River gravels consist of rounded brown cherts, white quartzes, glacial granites, some coal, and sand.

AN OHIO RIVER BOTTOM FARM AT ITS BEST.

This is a typical diversified farm southeast of Owensboro, Daviess County. In the view are cultivated fields of black Burley tobacco, corn, clover and oats. In the distance there is a fine young apple orchard and the size and character of the barns and silo indicate a dairy which means broad green pastures near by. Topography of the Quaternary sediments.

It is with an exclamation of surprise that one suddenly finds himself at the main ferry crossing the Green River. This is the stream whose name in an older day meant much to the lovers of mint julips, and other similar concoctions. It is a quiet, peaceful, smooth flowing river, bordered on either side by luxuriant rows of great forest trees which give it an altogether pleasing appearance. It is particularly a cool and restful spot just at nightfall, when with the long shadows creeping farther and farther over its limpid surface one hears in the distance the sleepy cry of startled water-birds, and feels the cool, damp odors of the many inland swales and quiet reaches.

THE OHIO RIVER CONTRIBUTION TO GOOD ROADS.
Ohio River gravel pile on Henderson wharf. This material is used with good results in many of the Kentucky counties adjoining the Ohio River.

At Henderson one sees heavy loaded coal trains of the L. & N. Railroad going North, and recalls that this county is one of the rich counties of the Western Coal Field, its production in 1918 having amounted to 394,062 tons valued at $955,613.00. In agriculture Henderson county takes a high place, having pro-

duced in 1918, 3,500,000 bushels of corn and 240,000 bushels of wheat. Much fruit is grown here, and it is conceded to be the leading apple exporting county of the state. The road to Uniontown runs along the South shore of the Ohio on Quaternary bottom-lands which are largely planted to corn and tobacco. This bottom-land is very sandy, and suggests the presence during some by gone geological time of the Ohio River in closer proximity to the Pottsville escarpment, which in the form of low rounded hills now rapidly melting away, lies just south of the main road.

Uniontown is a quaint little place picturesquely situated on the banks of the Ohio near the mouth of Highland Creek, and just above Wabash Island where the Wabash River, coming down from the north, makes its debouchure into the Ohio. In the lower part of Uniontown one gets the idea of occasional high waters, for the houses are all built up four or five feet on stone or brick abumtents. At present there is much interest in Uniontown over the development of a new shaft which will go down 300 feet to the No. 9 coal. This famous western Kentucky coal seam has been cored and found to be six feet thick under the Uniontown area. No. 11 coal is now being operated at Uniontown, as well as in other parts of Union county.

The road to Morganfield is exceedingly good and continues so southward to Sturgis, the home of the West Kentucky Coal Company, one of the largest producers of Union county coal. Statistics show that in 1918 there was produced in Union county 992,973 tons of coal valued at $2,213,394.00, which is larger of course than Hancock, Davies and Henderson combined for several years. Union county is also a great hay and corn producer. Its hay acreage will yield the high average of two tons. In 1918 it produced between 50,000 and 75,000 tons of hay and about 250,000 bushels of corn.

But a few miles south of Sturgis one comes abruptly on to Tradewater River which is crossed by a ferry and with little difficulty during times of low water. The ferry man will tell you, however, that during flood times its muddy banks make it an exceedingly dangerous stream. From the Tradewater south to Marion the road is rough, and one will find this the most difficult though none the less picturesque portion of the

THE GOOD GRAVEL ROADS OF DAVIESS.

Ohio River gravel is used to good advantage in road building in many parts of western Kentucky, as this view on the Owensboro-Livermore pike demonstrates. Topography of the Ohio River bottom alluviums.

whole trip. Almost unconsciously one slides off the Pottsville sandstones of the coal measures onto the surface of the Mississippian limestone rocks which form the greater portion of Crittenden county. It is here that the road gets rough.

At Marion one will want to go west four or five miles and see some of the splendid fluorspar mines of that section. While here, it is well to remember that Crittenden and Livingston

A NEW UNION COUNTY COAL MINE.
At the time this picture was taken the shaft was down 60 feet and going 300 feet to No. 9 coal, which is 6 feet thick. The operation is that of the Union County Mining Co., and is located at Uniontown.

county, but especially Crittenden, is the chief fluorspar producing section of Kentucky. This area, together with the adjacent portion of Illinois, supplies four-fifths of the large fluorspar market of the United States. Fluorspar is the chief mineral of value of Crittenden county, though lead and zinc occur in lesser quantities associated with the spar.

Fluorspar as a mineral name does not mean much to the average person. If he is reminded, however, that it is essential to the manufacture of the enamel of kitchen and bath room

supplies, that it is indispensable to the modern manufacture of aluminum, used in the making of glass, generally required as flux in the manufacture of iron and steel, and the base of hydrofluoric acid, which is used to etch glass, he will realize the importance of this glassy white mineral substance, and its value to Kentucky. At the Mary Belle mine west of Marion, or at Mexico, south of Marion, he will see great storage piles of fluorspar and

THE PEACEFUL TRADEWATER.

A hand ferry on the Tradewater River on the road from Sturgis to Marion. In this view the farmer is driving to Sturgis. Lack of adequate steel bridges over the lower waters of some of our western Kentucky rivers is a serious handicap to the full agricultural and mineral development of many sections.

will be told, if he takes the trouble to ask the question, that it is selling at between $30.00 and $50.00 a ton. The production of fluorspar in this field in 1918 was 87,604 tons, which was valued at $2,069,185.00.

The rougher and more broken country of Crittenden county gradually gives way to low rounded hills of Caldwell, in the vicinity of Princeton, where the tourist again sees many fine farming sections. Not the least of Caldwell county's industries is that of the preparation of ground limestone for agricultural

A CRITTENDEN COUNTY FLUORSPAR MILL.
A very large percentage of western Kentucky "spar" has to be milled. This is the plant of the Kentucky Fluorspar Co., located at Marion.

purposes. As a rehabilitator for worn out soils, it scarcely has an equal, and thousands of tons are exported annually from a number of quarries. At Eddyville one sees for the first time the Cumberland river which is now being locked at a point almost directly in front of the Kentucky State Prison. If he has the time, it will pay the traveler to climb up on the top of the prison power plant overhanging the river bank and view, as with the birds, the unusual industry below. Here are the steaming little scows and tugs, the swinging devil fish arms of the great barge derricks, the dinky trains shunting backward and forward, and all in and around, the unceasing toil of hundreds of men who in sweat and dirt and with many a curse are shaping new structures of steel and stone to hold back the waters of this great river.

The best ferry in this section is at Kuttawa, a quiet little hamlet on the Illinois Central Railroad, just west of Eddyville. The town is blessed with tall rows of forest trees overhanging the little homes, and in between down the center of the main

street a third row meets those on either side, giving a quiet and refreshing shade suggestive of the old south.

In "Between the Rivers," as the section is known from Kuttawa to the Birmingham ferry on the Cumberland, one will see a part of Kentucky which has remained largely unde-

A MARION FLUORSPAR MILL.

Plant of the Gugenheim Mining Co., located at the edge of the city and operating a low grade ore, from a view adjacent to the mill. Highly polished slickensided blocks of fluorspar taken from this property by the writer, indicate fault movement here under considerable pressure.

veloped during the last several decades. In this area are located the large forest preserves of the Hillman Land and Iron Company, approximating something like 55,000 acres. Within the boundaries of this great tract of timber there is to be found only an occasional native resident. Many of the houses in this section are old double log cabins with a single roof of hand made shingles. For those who are thirsty there is always a well or cistern of fine water on the porch between the cabin rooms. But watch out, for in the front yard just back of the white paling fence, is a trusty old bird dog dreaming of quail and

A WEALTH PRODUCER IN THE PURCHASE.

Black Burley tobacco six weeks old on the Dr. John Kirksey farm, near Sedalia, Graves County. During 1918 and 1919 this "weed" grew with much arrogance in many a west Kentucky door yard and widely displaced the normal staples of corn, hay, etc. The declining markets of 1919 and 1920 induced a large reduction in the acreage planted.

squirrels in the shade of a giant oak tree. Like the natives, he has a suspicious eye open for strangers, but will turn out to be a good fellow if rightly approached.

Little farming is carried on in this section, the soil being poor and the demand for agricultural products being very limited. The Hillman ferry at Birmingham is in itself worth the whole trip. Down the river is Seven Mile Island and the great white bluffs of Chester limestone known as the Star Lime Works. Up stream one sees One Mile Island with its tall forest trees which brings back memories of the beautiful channels of the St. Lawrence. All the way into Birmingham the conspicuous red sands, gravels and clays on each side tell one that he has left the more solid limestones and sandstones of the Paleozoic behind, and is now on the Quaternary sediments of the "Purchase" country.

The route from Birmingham to Benton leads through beau-

tiful stretches of woodland over roads which are fairly good in dry weather. Log cabins with "stick an' mud" chimneys gradually give way to better homes as one approaches Benton, though in this whole section the log built building, especially the towering old log barns, are a pleasant rural characteristic.

ON THE BANKS OF THE TENNESSEE.
The view is down the Tennessee River at Hillman Ferry. Star Lime Bluff and Seven Mile Island may be seen in the distance. Topography of consolidated Mississippian limestone on the right and unconsolidated Quaternary sands and clays of the Purchase on the left.

There are still it is estimated about 20,000 acres of timber in Marshall county.

From Benton to Murray, the county seat of Calloway, the road is very good, local gravels being used largely for its improvement. Murray is a thriving town, with an excellent new court house as its center. The agriculture of the Purchase begins to improve as one approaches Mayfield in Graves county, around which town are grouped hundreds of fine farms producing bumper crops of corn, and heavy loads of fine black burley tobacco. Graves county from Mayfield south to Lynn-

THE EARLY BIRD GETS THE WORM.
And such is the reasoning of the Graves County farmers who are here hauling black Burley tobacco to the Mayfield market over good gravel pikes.

ville has an excellent gravel pike, better than which there is none in the state. The road from Lynnville swings westward to Fulton, a thriving town on the Tennessee line,, thence over a broad and well graded pike, the Paducah to Memphis highway, to Hickman.

Here one sees for the first time from the bluffs of Lovers' Leap the broad expanse of the Mississippi river. It is indeed an inspiring sight. Below is the business townsite, the railroad yards, the wharfs, and in the distance the great plant of the Mengel Box Co., where hundreds of thousands of logs are annually consumed in a labyrinthine complex of whirring saws and gouging planes. Later all lacquered and glued and decorated beyond recognition, these scions of the forests of Kentucky, Tennessee, and the south, go forth into the world to fulfill their mission as cigar boxes, veneers, dashes for Ford cars, parts for aeroplanes and whatnot.

The road to Clinton in dry weather is made by way of

HICKMAN ON THE MISSISSIPPI RIVER.

The view is down the Mississippi River over Hickman townsite. Note that the business section of the town is on the low narrow flood plain where the river trade fixed it. The residential portion of the city is elevated on 150-foot bluffs from which inspiring panoramas greet one in every direction. Topography of Quaternary bluffs and Mississippi River recent lowland alluriums.

Moscow. Along the low lands of the Bayou De Chien, the farming is largely given over to the raising of corn and cotton. Fulton, the only county in Kentucky producing cotton, is particularly well adapted to its growth, since it is one of those out-

LOGGING ON THE MISSISSIPPI RIVER.
Unloading logs at the Mengel Box Co. wharf, Hickman. Here are made cigar boxes, dashes for Ford cars, airoplane parts, etc. Between 800 and 1,000 men and women are employed in this large western Kentucky industry. Topography of the Mississippi flood alluviums.

lying sections of the Cotton Belt into which, as yet, the boll-weevil has not penetrated.

In and about Arlington one will see large fields of luscious red tomatoes. Occasionally whole farms are given over in this part of Carlisle county to the raising of this vegetable, which is canned locally and also shipped to Paducah. In the vicinity of Bardwell, the low rounded hills of soft gravel loam produce excellent red clover, which may be seen stacked in abundance at every hand.

In dry summer weather the shortest road from Bardwell to Wickliffe leads directly down into the lower reaches of Mayfield creek, a stream of considerable size which has its head-

waters away to the southeast in Calloway county. At the point where the road crosses Mayfield Creek the Mississippi river is but a few miles removed, and naturally one finds the road bad even under the most favorable weather conditions. In times

IT'S RED CLOVER IN HICKMAN COUNTY.

The soil in many parts of the Purchase is well adapted to clover growing, and in Hickman County especially, large acreages of the wealth producing red top crop may be seen. Topography of the Quaternary unconsolidated and semi-consolidated sands, gravels and clays.

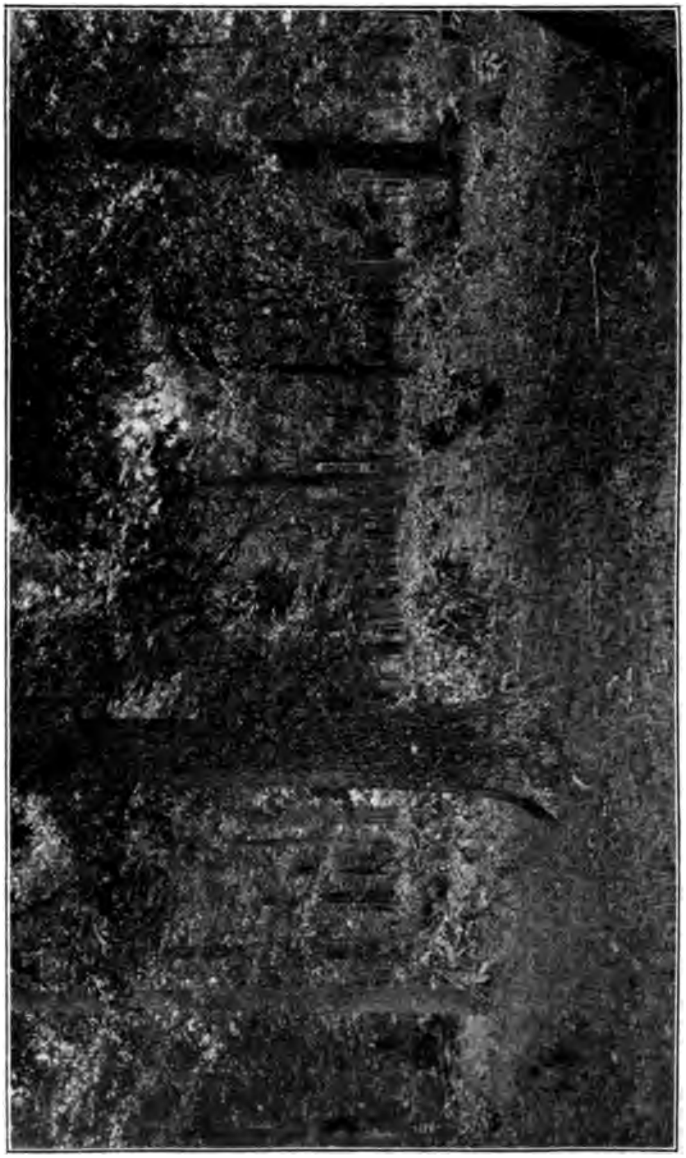
of wet weather, this road will be impassable. For he who has the time Mayfield Creek offers an opportunity for a fine fishing party since it bears a wide reputation in these lower stretches as the favorite haunts of all disciples of Isaac Walton.

A good bit of the road between Mayfield creek and Wickliffe is over the washed out and abandoned right-of-way of the Mobile and Ohio Railroad. This right-of-way was turned over to the county for road purposes by the railroad after the flood of 1912. The tracks and ties have been removed. So infrequent is the travel in this isolated section that the road is almost

WESTERN KENTUCKY FEATURES THE RED TOMATO.
Many a field of love-apples (tomatoes) may be found in Carlisle County near Bardwell as this view shows.

overgrown with grass and moss. Closing in from either side so as to give a twilight even at mid-day, the low bending branches of the bordering forest trees have made this part of the road on the old "right of way" little more than a trail.

At Wickliffe one should drive out on to the lowest flood plain of the Mississippi. Here if he is fortunate enough to have arrived toward sundown, he will find the most beautiful view in all western Kentucky. For as he looks up stream, he will see the "Father of Waters" coming down from the mountains and prairies of the northwest and meeting, and taking unto himself, his sturdy child, the Ohio. In between these two rivers stands the great Illinois peninsula on which the smoke-capped city of Cairo is situated. As the great red ball of the sun drops down into molten waters, one gets something of the inspiration which must have filled the hearts of the great La-Salle and those of the old Catholic Fathers, Joliet and Marquette, when they first beheld this magnificent Mississippi in the wilderness of the new world.



GROVES THAT ARE NATURE'S CATHEDRALS.

There are still many fine, though small, stands of poplar, hickory and oak in the southern part of the Purchase, as this view on the Paducah to Memphis highway near Hickman shows.

WAY DOWN SOUTH, IN THE LAND O' COTTON.
Here are one thousand acres of young cotton on the Kentucky shore of the Mississippi River. Hickman, the county seat of Fulton, may be seen in the distance on the bluffs of the river. Topography of the Mississippi River alluviums.

Shaking off the soliloquy inspired by this majestic panorama, one turns his eyes again to the east, and with an undulating but well graded gravel pike, he finds the thirty-eight miles through Ballard and McCracken counties to Paducah all too short. Excellent farms and prosperity are found on every side, and in Paducah, the metropolis of western Kentucky, he sees and feels the thrill once more of a fine modern and progressive city.

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VII.

THE ULTIMATE SOURCE OF KENTUCKY CRUDES.

The present intensive search for new oil production in the Appalachian district to bolster up the steadily declining volumes of all the older pools, is leading all thoughtful petroleum geologists to a careful consideration of the newly advanced theories as well as the established principles which have to do with the accumulation of crude oil in the natural rock reservoirs. Pertinent to this study is an inquiry into the natural and stratigraphic position of the ultimate source, or mother-rock of petroleum. This inquiry is indeed pertinent since it may not be fairly determined whether any "wild cat" area is to be listed as "probably productive," "possibly productive," or "barren," until it is definitely known whether that area contains either at shallow or greater depth a "competent" petroleum producing mother-rock. In many fields where certain productive sands are known to exist at estimated or known depths, it may also be, and frequently is, a vital consideration as to whether deeper drilling might or might not find below these known "pays" new productive horizons. Since these are questions with which every petroleum geologist is materially concerned, it is quite worth while that they receive careful consideration.

In the state of Kentucky there are now known and readily identifiable ten separate productive sands or groups of sands. These are as follows: The "Beaver," "Horton," and "Pike" of Floyd and Knott counties; the "Wages," "Jones," and "Epperson" of Knox county, in the Pottsville (Lower Pennsylvanian). Underlying these is found the "Maxon" or "Maxton" sand of the Chester or Mauch Chunk in southeastern Kentucky (Upper Mississippian). In the same area immediately below the "Big Lime" (St. Genevieve-St. Louis) occurs the "Big Injun" group of productive sands in the upper part of the Waverly (Lower Mississipian). Underneath these is found the "Wier" sand of the Lower Waverly (Lower Missis-

sippian) productive in a rather restricted area surrounding Magoffin, Johnson and Floyd counties in eastern Kentucky.

Separated from the overlying "Wier" sand by a few feet of shale is found the well known "Berea" sand of the basal Waverly (Lower Mississippian) in northeastern Kentucky, productive chiefly in Lawrence and some parts of Johnson counties. Correlating with the Waverly in southern Kentucky from Wayne county on the east to Logan county on the west, and Grayson and Ohio counties on the northwest, there is found in the "Warsaw" and "Fort Payne" (Lower Mississippian) limestones a series of disconnected and uncorrelated porous horizons which have received the various names of "Beaver Sand," "Amber Oil Sand," "Shallow Sand," and "Major Sand."

The next underlying crude oil producing horizon is found in the Onondaga or Corniferous (Middle Devonian) limestone where the oil occurs in porous streaks of varying thicknesses not identfiable as a true siliceous sand. This horizon is productive in the Estill, Lee, Powell, Wolfe, Menefee section of eastern Kentucky; and to the southwest into the Allen-Barren-Warren region. It is the great producing horizon of Kentucky, and is justifiably accredited with 95 per cent. of the present production of the state. Underlying the Corniferous limestone, and separated from it only with great difficulty in the well record is the Niagara (Silurian) limestone which is productive of oil in sandy porous streaks in the Lee county section of eastern Kentucky, and the Allen and Warren county portions of southern Kentucky. Immediately underlying the Niagara limestone, is found a long series of alternating hard and soft, and shaly limestones inter-bedded with thin to mediumly thick shales and very occasional thin sands, which have come to be known by drillers everywhere as the Trenton (Ordovician) group. Various productive sands known as "Sunnybrook" in the Wayne county field, the "Deep sands" and "Trenton" sands in other fields, have been found by the driller. Productive oil sands in this Trenton group are the lowest, stratigraphically, that occur in Kentucky.

The probable sources of the various oils encountered in these several sands is not easily determined. Consequently

there are a number of opinions now current which have been received with varying degrees of certainty and approval among geologists. There can be no doubt but what the Pottsville sands (Pennsylvanian) productive in the Eastern coal field secured their petrleums chiefly from adjacent thick bituminous shales, since there is nothing in the section other than the oil-containing or adjacent sandstones and sandy conglomerates, to serve as the mother-rock. The oils found in this group are high grade green oils, low in sulphur, with a Baume gravity of from 32° to 39°. They will show a gasoline fraction of about 21.5 in all the pools where the drilling depths are below 700 feet. In pools as shallow as 350 feet, the extreme porosity of these sands is well illustrated by the usual occurrence of black, stiff, devolatilized oils with a Baume gravity of from 18° to 22° and no trace of gasoline or lighter fractions.

Underlying the Pottsville, the Chester or Mauch Chunk (Upper Mississippian) shows in its contained "Maxon" sand a similar stratigraphical sequence of clastics except for the conglomerates, and as might be expected, the oils are similar in gravity and physical character to the overlying Pottsville oils. This fact caused them for many years to remain undifferentiated from the Pottsville production.* Their source is undeniably the adjoining red and green shales, and sands, since no other kinds of sedimentaries are found in the section. These contributing shales when examined on the outcrop, or in drill cuttings, are certainly not as bituminous as the shales of the Pottsville; yet the oil in many ways is similar. In that considerable section of red shales, red sandy shales and sandstones which underlie the very thick "Big Lime" (St. Genevieve-St. Louis-Mississippian) is found the production of the "Big Injun" group. This oil is reddish green in color, and shows the highest gravity (50.30°) and highest gasoline fraction (46.9) of any Kentucky crude oil. Oil production from the "Big Injun" horizon is extremely limited in this state, though gas production is rather common. There are not more than a half dozen wells in Lawrence and Johnson counties now producing

*The Status of the Mauch Chunk in Southeastern Kentucky as a Producer of Petroleum and Natural Gas, by W. R. Jillson. Ky. Geo. Sur., 1919.

oil from the "Big Injun" sand. Its physical source like that of the "Maxon" oil, much higher in the section, must necessarily be the adjoining red shales or "Red Rocks," and sandstones of the immediate section. The very high gravity and large percentage of volatile constituents of the "Big Injun" oil suggests that the lower "Wier" and "Berea" sands have probably contributed some of their lighter parts to the enrichment of this unusual Middle Waverly sand.

The oil production of the "Wier" sand developed within the last year in Johnson, Magoffin, Elliott, and Floyd counties is a green crude showing an average Baume gravity of 34.16°, and an average gasoline fraction of 12.78. The most remarable thing concerning the "Wier" oils, as determined from an examination of six analyses, is the variability of the gasoline fraction. It ranges from 3.0 to 19.2. The Baume gravity is regular. Basal Mississippian bituminous shales, the only rock strata adjoining this sandstone, and very possibly the somewhat lower lying Chattanooga or Black Shale (Devonian), must be looked upon as the ultimate sources of the "Wier" oils.

The "Berea" sand productive in Johnson, Elliott and Lawrence counties in eastern Kentucky shows in an examination of six analyses an average Baume gravity of 37.5°, and a gasoline fraction of 18.0. There is an element of some variability in the gravities of the "Berea" oils. In contrast, however, to the overlying "Wier" sand, the "Berea" shows a distinct tendency on the part of its gasoline fraction to remain close to 20. Sulphurs of all "Berea" oils have been found to be small, 25 per cent. or less, by weight.

A review of analyses of seven samples of oils taken from the "Beaver" or its equivalents (Lower Mississippian) in southern and western Kentucky shows an average Baume gravity of 37.74°, and an average gasoline fraction of 19.64. These oils are also found to be high in paraffin and low in sulphur. They vary in color from a light orange amber to a reddish or brownish green. In considering the source of the "Beaver" sand oils, one is lead to note the remarkable closness in a comparison of the averages of the "Berea" oils and the "Beaver" oils in both gravity and the gasoline fraction. In the samples as given which were selected at random, though widely dis-

tributed over the productive fields, the Beaver sand average Baume gravity is superior to the Berea by only .24°, and only 1.64 in the gasoline fraction. The colors of the two oils are similar, both being amber to light green, low in sulphur, and high in paraffin.

Carrying the comparison further, the Beaver sand oils show higher paraffin and lower sulphur than the Berea sand oils. The fact that the "Beaver" sands are not true silicious sands, but limestones, as compared to the real silica Berea sand, may account for the slight difference in the chemical constituency and physical characteristics of these oils. But the difference in the oils is so very slight as to suggest for them a common source. Initial distillation points of 46°, 50°, 56° and 60° centigrade are so low in both of these oils as to strongly suggest a common source of the lighter distillates which both contain. Since it is quite unreasonable to credit the rather thin, bituminous shale lying between the "Berea" and "Wier" sand as the only source of the "Berea" and "Wier" oils in eastern Kentucky; and since this shale has no exact counterpart in western Kentucky, though the "Berea" and "Beaver" oils remain essentially similar, it is but logical to turn to the thin underlying "Sunbury" (Mississippian) and relatively thick Chattanooga (Devonian) black and richly bituminous shales as the principal mother-rock. Such a conception for all of the sands above discussed in the Waverly of eastern and southern Kentucky from the "Big Injun" to the "Berea" and the "Beaver," is thoroughly in keeping with the latest and best conceptions of the principles of oil accumulation, migration, and commercial segregation into pools according to the degrees of folding, water saturation, and porosity of the oil-bearing rock strata.

In the consideration of the next lower oil horizon, the Onondaga or Corniferous (Devonian) limestone immediately underlying the Chattanooga (Devonian) black shale, arise all of those factors which would naturally attach themselves to the most important oil producing horizon of the state. The Onondaga limestone is underlain by a long series of thick and thin limestones and shales (Silurian and Ordovician). Being overlain by the richly bituminous Chattanooga shale, it was but natural that many geologists who have given but scanty thought to the

matter should assume the Chattanooga shale to be the petroleum source, or mother-rock. An examination of the analyses of eight specimens of crude oil from the Corniferous in almost as many counties in Kentucky shows an average Baume gravity of 35.7°, and an average gasoline fraction of 16.7, with the colors of the oils ranging from black to green, and the sulphurs ranging from slight to high. This and other examinations of the analyses of Corniferous oils exhibit a greater variability in the Baumes, gasoline fractions, burning oil fractions, the lubricating fractions, and the paraffin and asphaltic bases Sulphurs show a wide range from the sweet oils of the Lee county district to the sour oils of the nearby Lincoln county district and the somewhat distant Allen and Barren county district. The physical characteristics of the oils are also variable. The colors grading from light green with brownish green by transmitted light to black. Viscosities also show a wide range. Some of the instances of variation are due to devolatillization because of lack of adequate cover as in the Bath and Lincoln county pools but in the main the differences of constituency are inherent in the oils themselves, and the explanation must be found elsewhere.

In assembling the necessary data to throw light on the probable ultimate source of the Devonian oil in Kentucky, it is found that the arguments group themselves into two classes:

(1) Positive, or favorable to lower sources than the Chattanooga black shale.

(2) Negative, or opposed to the Chattanooga black shale as the source.

The positive arguments are as follows: (1) The occurrence of large centralized production in such pools as the Big Sinking in Lee county, and the Gainesville in Allen county, when considered in connection with the characteristic of a porosity rapidly decreasing to essential tightness toward the edge, indicates a relatively small lateral movement of the contained petroleums within the oil horizon (Corniferous) Devonian limestone. (2) A very large amount of "wild cat" drilling in Kentucky to the Devonian and Silurian limestones underlying the Chattanooga black shale (Devonian) has demonstrated that these formations

are generally compact, solid and unpetroliferous at relatively short distances removed from the outcrop or some line of structural disturbance. In the drilling term they are "dry" and too "tight" to produce even a "rainbow" showing, much less commercial oil. This well known "tight" condition of the Corniferous (Devonian) limestone over its greater area precludes any conception of lateral migration of petroleums within it under the buoyancy of connate water, or the pressure of hydraulic streams. (3) Since lateral migration is evidently a small factor in the accumulation of the Corniferous oils, it would be necessary for Chattanooga black shale if regarded as the source to contribute very large amounts of petroleum within relatively small areas. This condition is a prerequisite, since it would be impossible for small amounts of petroleum moving downward from a small area under the Chattanooga shale to ever form a large pool. It is thoroughly impossible to conceive of the Chattanooga black shale making any such large contribution to any small area as is represented by the quantity of oil found in such pools as the Bing Sinking or the Gainesville. (4) Deeper productive sands, probably Ordovician, have now been discovered in the heart of the Big Sinking pool in Lee county. Since all limestones are jointed and fissued to some extent it is only reasonable to assume that these lower Trenton (Ordovician) beds are directly connected in many places with the overlying Silurian and Devonian limestones and shales. (5) The remarkable similarity of the variation of "Corniferous," "Niagaran" and "Trenton" oils both in chemical analyses and physical characteristics indicates a common contributory source.

The negative arguments are as follows: (1) No oil has ever been found in Kentucky in the Chattanooga black shale or in contained sand or limestone lenses, which are known to occasionally occur in this stratigraphic unit from Floyd county in eastern Kentucky to Meade county in western Kentucky, and Allen county in southern Kentucky. (2) Gas alone has been found in the occasional porous lenticular inclusions of the Chattanooga shale. (3) The bituminous content of the Chattanooga black shale (½ to ¾ bbls. to the ton) does not now exist as free petroleum, but as kerogenitic matter. requiring distructive distilla-

tion for its liberation. (4) The Chattanooga black shale shows similar analyses over areas of large oil concentration, and over areas of known barrenness, thereby exhibiting no evidence of deterioration of its contained kerogens in the process of petroliferous enrichment of underlying formations such as the Corniferous, or Niagaran, or Trenton limestones, as the case may be. (5) The small amount of oil found in the Berea and Beaver sands above the Chattanooga shale with every favorable condition attending indicates the slight contribution of this black shale unit to the oil sands adjacent to it. (6) The varying analyses and character of the Berea and Beaver oils with the Corniferous oils points conclusively towards widely differing sources for each group of petroleums. Assuming the Chattanooga black shale to be the principal source or mother-rock for both of these oils, they should naturally be expected to show much similarity chemically and physically, since the Chattanooga black shale exhibits as one of its principal characteristics a dull black uniformity of color, bituminous content, lithological and fossiliferous characteristic. (7) At many points in the Allen and Simpson county fields, the Chattanooga black shale is directly underlain by a thin definite sandstone which is generally found to be slightly gassy, but has never been known to contain oil in commercial quantities. If the Chattanooga black shale were the mother-rock for the Corniferous or Niagran oil which is found in these above named sections in commercial quantities underlying this gas horizon, and separated from it by a pronounced and very hard capped limestone, what will explain the absence of oil in gas sand horizons just below the shale? (8) Commercial oil is found in the Corniferous limestone only in those sections where a hard and impenetrable cap rock exists above the porous oil horizon. If this cap rock is at the present dense enough to effectually stop the upward and outward migration of the oils in the Corniferous limestones, at what time was it soft enough to allow the downward migration through it of large quantities of petroleum from the overlying Chattanooga black shale, and yet never have retained within itself even a smaller portion of them? (9) The downward migration of Chattanooga black shale free petroleums could only be brought about through a conception of the

black shale as an essentially dry rock strata. It cannot be shown that the Chattanooga black shale with its charge of connate water was ever any drier, if as dry, as it is at present. The amount of moisture which it must always have contained could then have only acted to retard any capillary attraction of the more porous limestone or sandstone beneath it.

Underlying the Devonian limestone is found the Niagaran (Silurian) limestone which produces oil in Lee county, and in Allen and Warren county from sandy, porous streaks. The oil produced shows a Baume gravity of 32.75°, and a gasoline fraction which will vary from 9.3 to as high as 18.5. The color is green and the oil is rather high in sulphur in the Allen county field, though not noticeably so in other fields. These "pay" horizons in the Niagaran limestone are surrounded by thin green to gray calcareous shales, which though low in bituminous matter, must have served in part as the mother-rock. In the case of the Silurian limestone, however, as in the overlying Devonian limestone, a careful examination of all the evidence at hand points to a gradual petroliferous enrichment along vertical or semi-vertical porous channels or planes from original sources well down in the underlying Ordovician section.

The series of productive horizons which occur in the Ordovician directly inferior to the above discussed Niagaran limestones is not well defined in Kentucky, and consists principally of porous lenses or "strays" in the limestone proper. It is impossible to correlate these productive horizons over detached areas into any definite sand or groups of sands, but they have generally received the title of "Sunnybrook" for the upper horizons, and "Trenton" for the lower. The commercial production of this group of "sands" is confined principally to Barren, Monroe, Cumberland, Clinton, Wayne and Russell counties in southern Kentucky. It is suspected, however, that this long series of limestones between 1500 and 2500 feet thick has at one time or another contained, perhaps, commercial production over a much larger area, since seepages are very common at numerous and widespread points throughout the central Bluegrass area where the rock comes to the surface in outcrop. A study of the analyses of this group of oils shows an average Baume gravity of 35.08°, and an average gasoline fraction of 9.72.

Sulphurs are variable from low to high, and the color is generally an olive green.

The average gravity and average gasoline fraction, however, does not show the extreme variation which may be found in these Ordovician oils. The Baume gravity in separate analyses actually varies from 31.3° to 40.3°, and the gasoline fraction from 2.5 to 27.5. This feature of variability, it will be seen at once, is in strict accord with the facts as developed in connection with the Silurian oils and Devonian oils, and places these crudes which occur lower than the Chattanooga black shale in something of a companionship of probable source. Their points of similitude are many besides that of variability of analyses. They are all limestone oils, and are all surrounded by thin and meagerly bituminous calareous shales. It is of course impossible to conceive of any oil which might be found in the Trenton rocks at several hundred feet below the Chattanooga black shale as having been derived from the Chattanooga black shale. Such oils must necessarily have been derived from adjacent and probably lower Ordovician beds.

The newest Trenton strike in Kentucky occurs in Clinton county near Beech Bottom where a productive Trenton horizon has been found at a depth of 1700 feet below surface, and approximately 1200 feet below the black shale. This oil (No. 34 of the analyses attached) shows a Baume gravity of 40.30°, and a gasoline fraction of 27.5, and is one of the lightest and most volatile oils of this state. The shallower production of the Trenton horizons in Cumberland and Barren counties shows the heaviest Trenton oils, and this is especially true where the Chattanooga black shale (Devonian) is not present above the limestone as a cover The inference clearly is that the Ordovician oils when protected by a good cover may be expected to be found as light and highly volatile crudes, but always with a large variation in their chemical analyses and physical characteristics This is what should naturally be expected since the "pay" horizons represent accumulations of petroleums from widely separated stratigraphical units, and therefore long and changing periods of geologic time. In accordance with the present understanding of life in the marine Ordovician oceans of the Appalachian region, it is only logical

to conceive the sources of these Ordovician oils to have been the adjacent calcareous shales and limestones themselves, the original petroleums being derived from the measureless mass of entombed organic matter which was principally animal in its origin.

An index list of some of the analyses of Kentucky oils used in arriving at the above conclusions is herewith appended.

INDEX ANALYSES OF KENTUCKY CRUDES.

ARRANGEMENT IN STRATIGRAPHIC SEQUENCE OF THE PRODUCING SANDS.

POTTSVILLE (LOWER PENNSYLVANIAN) SANDSTONES.

"Beaver," "Horton," "Pike" (Floyd and Knott).
"Wages," "Jones," "Epperson" (Knox).

	County—Pool	Lease	Baume	Gas Fract.	Sulphur
1.	Magoffin, Short Fk	J. Wright	22°	trace	....
2.	Knott, Beaver Ck	M. Amburgy	39°	21.5	0.12

CHESTER-MAUCH CHUNK (UPPER MISSISSIPPIAN) SANDSTONES.

"Maxon" or "Maxton" Sand.
(These oils not separated from Pottsville oils.)

BIG INJUN (LOWER MISSISSIPPIAN) SANDSTONES.

"Big Injun," "Squaw" and "Keener" Sands.

	County—Pool	Lease	Baume	Gas Fract.	Color
3.	Johnson, Toms Ck	Tom Osborn*	52.3°	46.9	Reddish-green

*(This sample contained a fractional admixture of Berea oil. Since this lower sand is also producing sightly in this well, no well producing from the Big Injun alone is known in Kentucky.)

CUYAHOGA (LOWER MISSISSIPPIAN) SANDSTONES.

"Wier" Sand.

	County—Pool	Lease	Baume	Gas Fract.	Color
4.	Magoffin, Paint Ck. Dome	M. Wheeler	36.8°	18.	Green
5.	Magoffin, Paint Ck. Dome	J. Blanton	31.1°	8.	Green
6.	Johnson, Paint Ck. Dome	C. Meade	33.4°	10.5	Green
7.	Magoffin, Paint Ck. Dome	H. Conley	34.7°	18.	Green
8.	Magoffin, Paint Ck. Dome	B. L. Wheeler	34.7°	3.	Green
9.	Magoffn, Paint Ck. Dome	V. Daniels	....	19.2	Green
		Average	34.16°	12.78	

BEREA (LOWER MISSISSIPPIAN) SANDSTONES.

"Berea" Sand

	County—Pool	Lease	Baume	Gas Fract.	Color
10.	Johnson, Wildcat	I. G. Rice	33.5°	9.0	Green
11.	Johnson, Wildcat	D. Davis	35.3°	14.5	Green
12.	Lawrence, Busseyville	W D. Owens	38.7°	21.2	Green
13.	Lawrence, Busseyville	R. J. Peters	38.5°	21.2	Green
14.	Lawrence, Yatesville	M. Herd	40.7°	21.5	Amber green
15.	Lawrence, Fallsburg	J. Collinsworth	38.3°	20.8	Amber green
		Average	37.5°	18.0	

*(The sulphurs of all above Berea oils was 25% or less by weight.)

WARSAW-FORT PAYNE (LOWER MISSISSIPPIAN) LIMESTONE.

New Providence—"Beaver" Sand and equivalents.*

	County—Pool	Lease	Baume	Gas Fract.	Color
16.	Warren, Wildcat	V. Humbrecht	36.7°	20.0	
17.	Warren, Wildcat	A. Covington	34.4°	14.5	
18.	Warren, Wildcat	S Thomas	35.9°	20.0	Green
19.	Warren, Wildcat	J. Britt	44.8°	25.0	
20.	Warren, Wildcat	R. W. Covington	33.9°	13.	Green
21.	Wayne	A. J. Roberts	38.0°	25.8	Green
22.	Barren, Oil Cty	Jordan	39.5°	19.2	Amber
		Average	37.74°	19.64	

*(The Beaver oils are all high in paraffin and low in sulphur.)

ONONDAGA-CORNIFEROUS (DEVONIAN) LIMESTONE.

	County—Pool	Lease	Baume	Gas Fract.	Color
23.	Barren Oskamp	Oskamp	36.9°	18.1	
24.	Warren		33.6°	13.0	Green
25.	Warren, Wldcat	Hunter	37.2°	20.2	Green
26.	Lee, Big Sinking		42.5°	16.0	Green
27.	Estill, Irvine		34.8°	17.0	Green
28.	Simpson, Reeder	Reeder	39.9°	27.0	Green
29.	Lincoln, Green River	H. Floyd	29.8°	17.0	Black
30.	Lincoln, Green River	H. Floyd	30.9°	19.0	Black
		Average	35.7°	18.41	

NIAGARA (SILURIAN) LIMESTONE.

	County—Pool	Lease	Baume	Gas Fract.	Color
31.	Warren, Wildcat	J. B. Sumpter	31.9°	9.3	Green
32.	Warren, Wildcat	W. O'Neal	33.6°	14.5	Green

TRENTON (ORDOVICIAN) LIMESTONE.

	County—Pool	Lease	Baume	Gas Fract.	Sulphur
33.	Barren, Temple Hill	E. Duncan	32.4°	2.5	1.01
					Color
34.	Clinton, Spring Ck.	J. W. Seldidge	40.3°	27.5	Green
35.	Cumberland, Od American	C. E. Edens	33.8°	8.5	Green
36.	Cumberland, Old American	G. W. Burchett	37.6°	17.6	Green
37.	Cumberland, Renox Ck	Ed. Baker	31.3°	2.5	Green
		Average	35.08°	9.72	

CUMBERLAND PIPE LINE.

Including runs from Estill, Lee, Powell, Wolfe, Wayne and Floyd Counties.

	County	Location	Baume	Gas Fract.	Sulphur Color
38.	Magoffin	Ivyton	37.7°	20.0	Green

Manuscript completed Aug. 31, 1920.

VIII.

PRODUCTION OF FLUORSPAR IN WESTERN KENTUCKY.

The unprecedented development of the fluorspar industry in Western Kentucky during the latter part of the World War period (1917-1918) has focused the attention of the State generally on the mineral and mining possibilities of this section. The

BEAUTIFUL AS A GEM.

Amethystine crystaline fluorspar is rather common both in appearance and in occurrence in western Kentucky. But a slab of the size of this one—18 inches across—which was taken from the Holly mine in Crittenden County, is as really beautiful as it is rare.

chief interest is principally included within the limits of Crittenden county, though commercial operations are also found in Caldwell and Livingston counties, and the fluorspar mineralized

section may be said to include not only the above named counties, but also Lyon, Trigg and Christian counties in Kentucky, as well as the adjoining counties of Pope and Hardin across the Ohio river in Illinois.

In the year 1920 there were thirty active and thirty inactive operations in Crittenden, Livingston, and adjoining counties. This development represents a decrease from the peak development which was reached in 1918 when these sixty operations and several others now abandoned were operating. The total tonnage of 1918 was 87,604, evaluated at $2,069,185,

MOUNTAINS OF GRAVEL FLUORSPAR.
Here is enough fluorspar to surface 100,000 bath tubs, 12,000 tons in storage at the Mary Belle mine near Marion, Crittenden County, Ky.

or an average price per ton of $23.62. The present conditions more nearly approximate the pre-war conditions of 1916-17, when there were fourteen operations in Crittenden, one in Caldwell, and one in Livingston.

Fluorspar from the Kentucky-Illinois district was first discussed by Henry Schoolcraft in 1819 in the American Journal of Science in 1st Series, Vol. 1, pages 52 and 53. The first oper-

LIVINGSTON AND CRITTENDEN COUNTIES.
Sketch map showing the location of the western Kentucky Fluorspar field and its rail and river connections. The position of the adjoining counties whether fluorspar producers or not is indicated.

ations were those of a company headed by Andrew Jackson in 1835 at the Columbia Mines in Crittenden county. David Dale Owen in 1854 in Series 1, Vol. 1, pages 87 and 89 of the Kentucky Geological Survey Reports, was the first to call attention to the need for development of the veins of Crittenden and Livingston. In 1874 a number of shafts had been operated, chief of which were the Columbia, Memphis, Larue, Holly, etc., in Crittenden; the Royal, Henry Woods, Robt. Woods, Tisdale, Donake, etc., in Livingston county, and the Marble Mines in Caldwell.

Statistics of production from 1896 to and including June, the first half of the year 1920, are presented herewith. The

FINE GRAVEL FLUORSPAR.

Much of the gravel fluorspar produced by the mines of western Kentucky crumbles soon after it is exposed to the air, and in some instances, as in the case of this sample taken from 300-foot level of the Mary Belle mine, it becomes as fine as coarse sugar or salt. The photo is reduced to one-half its natural size.

production in 1896 was 1500 short tons, valued at $8,250. In 1903 this had risen to 30,835 tons, valued at $153,960. There followed then a depression culminating in 1908, when only 6,323 tons were produced. From this on there had been a gradual rise in production of fluorspar in Kentucky to 1918, when the peak tonnage of 87,604 was reached. The tonnage

AN EXCELLENT FLUORSPAR VEIN.

The view is at the quarry face at the end of the north entry, on the lowest or 300-foot level in the Mary Belle Mine in Crittenden County. The actual width of the vein may be noted by comparison with the length of the writer's arm which though extended lacks a foot or more of touching the opposite wall rock. Thousands of gallons of crystal-clear, cold water pour into this entry daily through numerous ceiling fissures requiring the constant operation of large steam pumps.

for the first half of the year 1920 was 19,915 tons, valued at $493,880. The tot_l tonnage for 1920 is estimated at 25,000 short tons, which is at once indicative of a slumped market due to the reaction of the national steel industry.

Fluorspar produced in the Western Kentuck field must be 85 per cent pure to be of commercial grade. Ores as low as 40 per cent pure are profitably worked, however, during periods of strong market by milling, and are then sold as gravel fluorspar. Recent estimates of production show that about 75 per cent. f the total output of this field is gravel or milled spar. The percentage of the lump spar is small. That of acid fluorspar is almost inconsiderable as compared to the other grades, yet at $50 and $75 a ton (prices of 1920) it finds a higher, stronger, and more steady market than the gravel and lump grades, which sold during the year for from $20 to $42 per ton, F. O. B. Marion, Ky.

Herewith are presented statistics covering the production of fluorspar of Western Kentucky. There is appended a list of operators in the field.

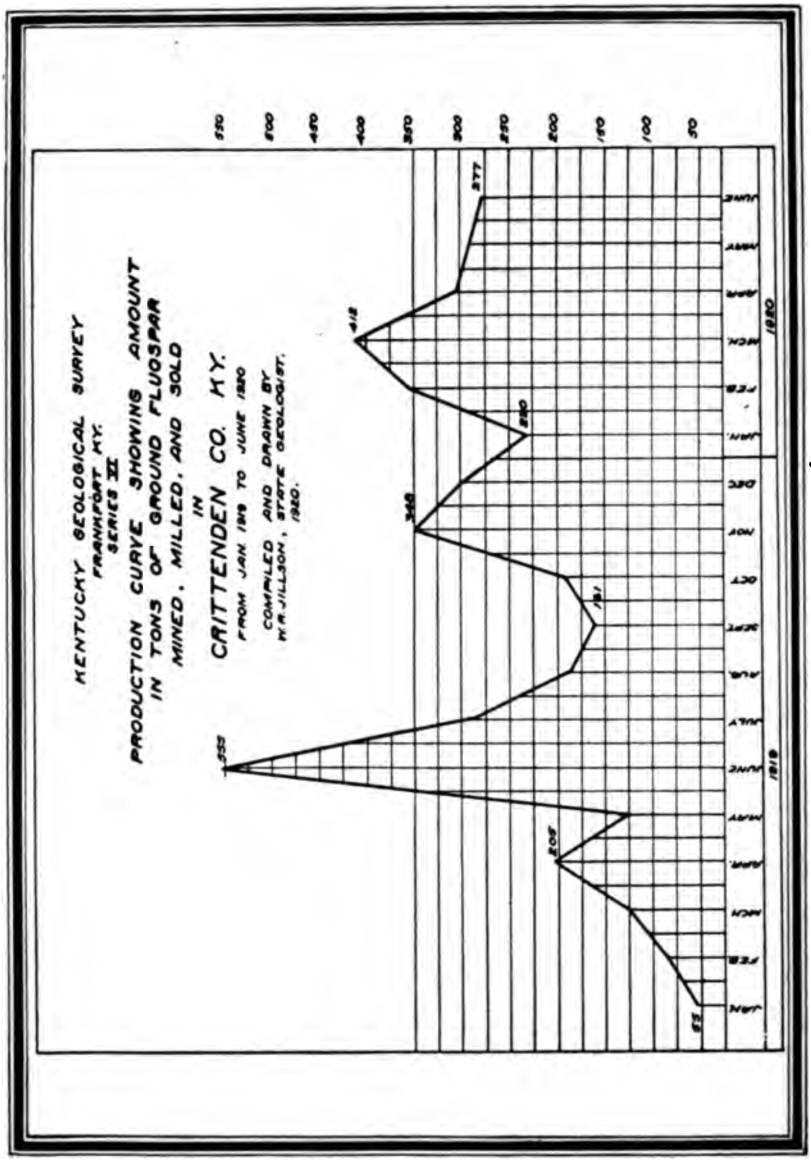
GRAVEL FLUORSPAR.

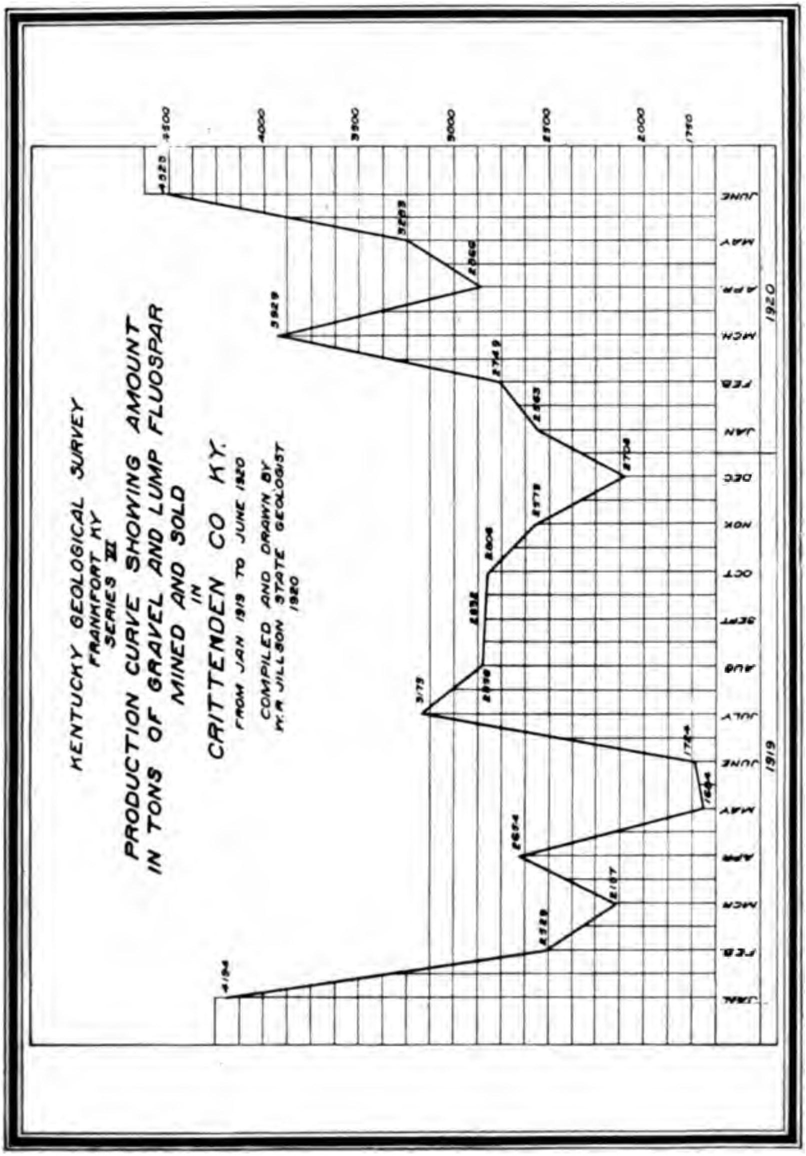
This sample of gravel fluorspar is representative of the best grade product and was taken from the large storage yards at Mexico, Crittenden County, Kentucky, by the writer. It is reproduced in its actual size.

THE PRODUCTION OF FLUORSPAR IN KENTUCKY FROM 1896 TO 1920 INCLUSIVE.

Year	Short Ton	Value	Or Price Per Ton
1896	1,500	$8,250	$5.50
1897	2,562	14,091	5.50
1898	5,000	34,000	6.80
1899	6,500	46,100	7.17
1900	8,500	53,135	6.25
1901	13,500	80,119	5.93
1902	29,030	143,410	4.94
1903	30,835	153,960	4.99
1904	19,096	111,499	5.84
1905	22,694	132,362	5.83
1906	11,793	75,156	6.37
1907	21,058	133,971	6.36
1908	6,323	48,642	7.69
1909	7,800	53,233	6.82
1910	17,003	124,574	7.33
1911	12,403	96,574	7.79
1912	22,882	151,130	6.60
1913	19,622	113,903	5.80
1914	19,077	128,986	6.76
1915	27,111	150,736	5.56
1916	24,796	166,736	6.73
1917	43,639	697,566	15.98
1918	87,604	2,069,185	23.62
1919	33,928	906,509	26.71
*1920	19,915	493,880	24.80

*The figures given for 1920 cover the first six months of the year only, e. g., Jan., Feb., Mar., Apr., May and June, 1920.


KENTUCKY GEOLOGICAL SURVEY
FRANKFORT KY.
PRODUCTION CURVE SHOWING AMOUNT
IN TONS OF GROUND FLUORSPAR
MINED, MILLED, AND SOLD
IN
CRITTENDEN CO. KY.
FROM JAN 1919 TO JUNE 1920
COMPILED AND DRAWN BY
W.R. JILLSON, STATE GEOLOGIST.
1920.
1919
1920

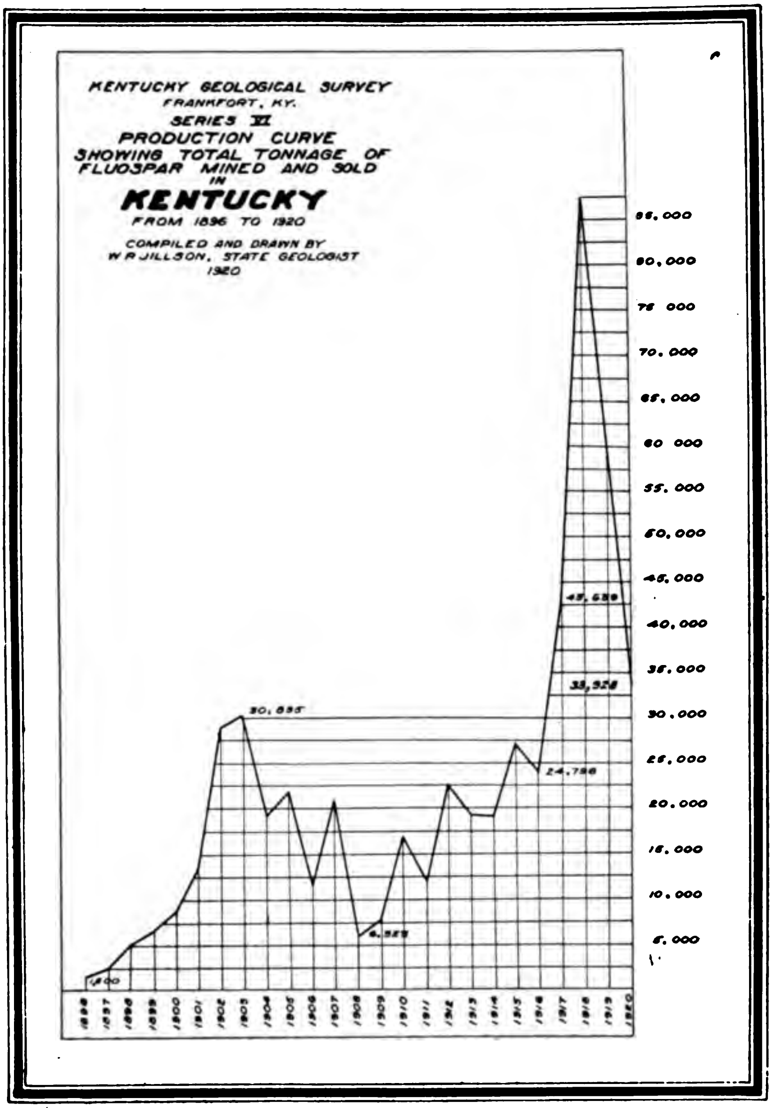

KENTUCKY GEOLOGICAL SURVEY
FRANKFORT KY
PRODUCTION CURVE SHOWING AMOUNT
IN TONS OF GRAVEL AND LUMP FLUOSPAR
MINED AND SOLD
IN
CRITTENDEN CO KY.
FROM JAN 1919 TO JUNE 1920
COMPILED AND DRAWN BY
W. R. JILLSON STATE GEOLOGIST
1920
1919
1920

FLUORSPAR SHIPMENTS FROM CRITTENDEN COUNTY IN TONS AND HUNDREDTHS

Month	Marion				Mexico			Crayne	Total Gravel and Lump Tons	Estimated Value f. o. b.	Total Ground Tons	Estimated Value f. o. b.
	Gravel	Lump	Ground	Lead	Gravel	Lump	Lead	Gravel				
1919												
Jan.	1,678.04	....	55.17	....	2,471.38	44.91	....	....	4,194.33	$113,246.91	55.17	$2,041.29
Feb.	1,265.50	....	86.5	....	1,103.55	160.24	....	....	2,529.29	68,290.83	86.5	3,200.50
March	1,286.3	5.4	121.42	....	883.75	....	....	....	2,157.45	56,093.70	121.42	4,613.96
April	1,546.6	44.0	205.61	57.65	1,020.36	....	....	44.0	2,654.96	71,683.92	205.61	7,607.57
May	495.24	....	127.78	....	1,156.07	....	....	33.0	1,684.31	43,792.06	127.78	4,855.64
June	864.66	....	555.51	30.0	785.8	74.1	....	....	1,724.56	43,114.00	555.51	20,553.87
July	1,963.0	44.0	290.61	20.76	936.87	141.62	....	88.0	3,173.49	79,337.25	290.61	11,043.18
Aug.	1,961.5	....	186.1	....	811.61	53.41	....	30.45	2,856.97	71,424.25	186.1	7,444.00
Sept.	1,558.21	55.0	161.37	....	1,063.97	39.6	....	116.0	2,832.78	70,819.50	161.37	6,454.80
Oct.	1,840.0	40.23	191.8	....	655.93	237.51	....	33.0	2,806.67	70,166.75	191.8	7,672.20
Nov.	1,268.58	44.0	348.93	....	1,171.16	90.15	....	....	2,573.89	64,347.25	348.93	13,957.20
Dec.	778.67	33.0	301.04	33.0	1,191.12	72.5	....	33.0	2,108.29	52,707.25	301.04	12,041.60
									31,296.99	$805,023.67	2,631.84	$101,485.81
											31,296.99	805,023.67
Grand total for year 1919									....	....	33,928.83	$906,509.48

FLUORPAR SHIPMENTS FROM CRITTENDEN COUNTY IN TONS AND HUNDREDTHS—Continued.

Month	Marion				Mexico			Crayne	Total Gravel and Lump Tons	Estimated Value f. o. b.	Total Ground Tons	Estimated Value f. o. b.
	Gravel	Lump	Ground	Lead	Gravel	Lump	Lead	Gravel				
1920												
Jan.	1,194.15	40.0	230.53	....	1,227.57	101.36	....	....	2,563.08	$64,077.00	230.53	$9,221.20
Feb.	1,046.31	45.0	366.37	....	1,107.55	507.98	7.42	42.6	2,749.44	64,736.00	366.37	14,654.80
March	1,494.0	74.0	412.12	....	2,213.95	147.8	....	....	3,929.75	98,243.75	412.12	16,484.80
April	946.15	....	305.23	....	1,861.47	58.67	....	....	2,866.29	71,657.25	305.23	12,819.66
May	1,452.5	46.0	290.2	....	1,652.62	132.2	....	....	3,283.32	82,083.00	290.2	12,181.20
June	2,210.00	66.0	277.47	....	2,103.65	143.7	....	....	4,523.35	113,083.75	277.47	11,931.21
									19,915.23	$493,880.75	1,881.92	$77,292.87
											19,915.23	493,880.75
Grand total for January to June, 1920, inclusive									....	....	21,797.15	$571,173.62


KENTUCKY GEOLOGICAL SURVEY
FRANKFORT, KY.
SERIES VI
PRODUCTION CURVE
SHOWING TOTAL TONNAGE OF
FLUOSPAR MINED AND SOLD
IN
KENTUCKY
FROM 1896 TO 1920
COMPILED AND DRAWN BY
W R JILLSON, STATE GEOLOGIST
1920
85,000
80,000
75 000
70,000
65,000
60 000
55,000
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
1896
1897
1898
1899
1900
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
1917
1918
1919
1920

LIST OF ACTIVE FLUORSPAR MINES.

1. Aluminum Ore Company, Mexico, Kentucky—Haffaw Mines.
2. American Fluorspar Company, Wheeling, West Va., and Salem, Ky.—Hudson Mine, Spar and Zinc.
3. Central Spar Mining Company, Marion, Kentucky—Gill.
4. Davis Mining Company, Hopkinsville, Ky.—Matthews Mine.
5. Denny, O. S., Marion, Kentucky—Mine near Mexico, Kentucky.
6. Dixie Mining Co., Marion, Ky.—Corn Mine.
7. Eagle Fluorspar Co., Salem, Ky.—Hearne.
8. Eclipse Mining Co., Louisville, Ky.—Commodore Mine (lease expired).
9. Fairview Fluorspar and Lead Co., Marion, Ky.—Franklin Mine.
10. Frazer, Jim, Princeton, Kentucky—Mine 6 miles north of Princeton.
11. Guggenheim Mining Co., Marion, Kentucky—Lucille Mine.
12. Haynes, C.W., Marion, Kentucky—Butler Mine.
13. Holly Ore and Mining Co., Marion Ky.—Holly Mine.
14. Kentucky Fluorspar Company, Marion Ky.—Brown Mine, Susie Beeler Mines, Yandell Mine, Pogue Mine, Mary Belle Mine.
15. Marion-Nashville Fluorspar Company, Marion, Ky.—Cox.

AN UP-TO-DATE FLUORSPAR OPERATION.
This is an excellent panorama of the Aluminum Ore Co.'s mill, shaft, derricks and power house at Mexico, Crittenden County, Ky.

16. Mitchell, W. P., Marion, Ky.—Macer.
17. Myers & Cryder, Mexico, Ky.—Nancy Hanks
18. National Fluorspar Co., Union City, Tenn.—Mitchell Mine.
19. Pope Bros., Louisville, Ky.—Babb Mine, Livingston County.
20. Rawn, E. V., Hopkinsville, Ky.—Marble Mine.
21. Reed, A. H., Marion, Ky.—Big Four Mine, Macer, Fred Brown, Deer Creek Springs.
22. Royal Mining Co., New Orleans, La—Spar, Zinc.
23. Southern Mineral Company, Mexico, Ky.—Pogue Mine, Paris Mine, Rider Farm.

THE MEXICO STORAGE YARD.

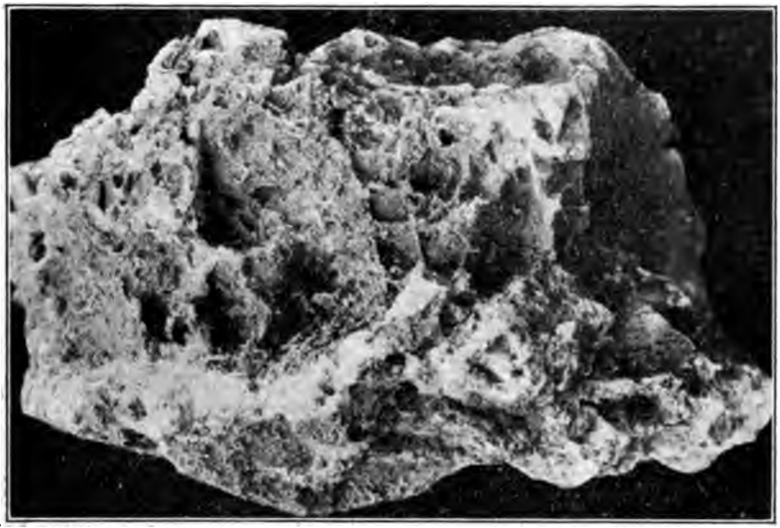
Literally thousands and thousands of tons of fluorspar were heaped in this yard in June, 1920, by the Southern Mineral Co., Kentucky Fluorspar Co., the West Kentucky Fluorspar Co., and the Keystone Fluorspar Co., awaiting cars for railroad shipment.

24. Standard Spar Mining Co. of North America, Chicago, Ill., and Marion, Ky.—Eaton Mine, Keystone Mine.
25. Stribling, E. G., Marion, Kentucky—Hardin or Red Fox Mine.
26. United Mining Company, Canton, Ohio, and Lola, Ky.—Bonanza Mine.
27. U. S. Fluorspar Co., Marion, Ky.—K. K. Mine.
28. West Kentucky Ore Co., Marion, Ky.—Tabb Mine, Larue Mine.
29. White Fluorspar Company, Marion, Kentucky—Glendale Mine.
30. Zinc Spar Mining Co., Marion, Ky.—Ebbie Hodge Mine.

LIST OF INACTIVE FLUORSPAR MINES.

1. Aluminum Ore Company, Mexico, Kentucky—Memphis and Klondike Mine.
2. Clay Lick Fluorspar Company, Marion, Ky.—Davenport.
3. Clay Lick Fluorspar Company, Marion, Ky.—Redd.

4. Commodore Fluorspar Company, Hopkinsville, Kentucky.
5. Commodore Mining Company, Louisville, Kentucky—Commodore Mine, leased to Haynes & Clark.
6. Crittenden County Lead, Zinc and Fluorspar Company, Marion, Ky.—Butler Mine, leased to C. W. Haynes.



PITTED LUMP FLUORSPAR.

This sample shows in much detail the pits which are developed in some grades of fluorspar by the leaching out of the included carbonate of lime. Photo four-fifths natural size.

7. Crosson Cave Mining Co., Marion, Ky.—Crosson Mine
8. Denny, O. S., Marion, Ky.—Eva Tanguay Mine.
9. Farris Fluorspar Co.—Paducah, Ky.—Porter Mine.
10. Farris Company, Paducah, Ky.
11. Farris & Shemwell, Paducah, Ky.—Bateman Mine.
12. Frazer, Jim, Princeton, Kentucky.
13. Haynes & Clark, Marion, Ky.—Commodore and Eclipse Mines.
14. Hill, D. B., Hopkinsville, Ky.—Edwards Mine.
15. K. K. Mining Company, Marion, Ky.—Property leased to U. S. Fluorspar Co.
16. Ken-See Mining Company, & O. K. Oil Co., affiliated companies.
17. Kentucky Fluorspar Co.—Ada Florence Mine, Beard Mine, Corn Mine, Susie Beeler Mine, Wheatcroft Mine.
18. LaGrange Mining Company, Marion, Ky.—Ebbie Hodge Mine.
19. Mineral Ridge Mining Company, Paducah, Ky.
20. Myers & Crider, Mexico, Ky.—John Hodge Mine.
21. National Fluorspar Company, Union City, Tenn.—Johnson Mine.

22. North American Lead & Fluorspar Corporation, Smithland, Ky.—Klondike Mine and Royal Mine.
23. Pasco Mining Co., Marion, Ky.
24. Phelps & Hazelip, Paducah, Ky.—John Hodge Mine, leased to Myers & Crider.
25. Pope Mining Company, Louisville, Ky.—Pope Mine.
26. Pope Mining Company, Louisville, Ky.—Watson Mine.
27. Reed, A. H., Marion, Ky.—Deer Creek Mine.
28. Roberts Fluorspar Co., Marion, Ky.—Tabor & Ashbridge Mines.
29. Tennessee Mining Co., Nashville, Tenn.—Ben Belt Mine.
30. White Fluorspar Company, Marion, Ky.—Reiter Mine.

LIST OF FLUORSPAR COMPANIES OUT OF EXISTENCE.

1. Ben Mac Mining Co., Marion, Ky.*
2. Dixie Mining Co., Marion, Ky.*
3. Federal Spar Co., Marion, Ky.*
4. Standard Spar & Chemical Co., Marion, Ky.*
5. Rosiclaire Lead & Fluorspar Co., Rosiclaire, Ill.—Pigmy Mine at Mexico, Ky., abandoned.
6. Southern Fluorspar Co.—Absorbed by Kentucky Fluorspar Co.
7. Senator Mining Co., Princeton, Ky.

LIST OF THE PRINCIPAL ACID FLUORSPAR CONSUMERS PURCHASING IN THE WESTERN KENTUCKY FIELD IN 1920.

1. General Chemical Co., Pittsburg, Pa.
2. John C. Wiarda, Brooklyn, N. Y.
3. Aluminum Ore Co., East St. Louis, Ill.
4. E. J. Lavine, Philadelphia, Pa.
5. Matthew Eddy, Chicago, Ill.
6. National Enameling Co., Cleveland, O.
7. Ball Bros., Muncie, Ind.

LIST OF THE PRINCIPAL STEEL INDUSTRIES PURCHASING FLUORSPAR IN 1920 FOR PURPOSES OF FLUX.

1. United States Steel Corp., Pittsburg, Pa.
2. Illinois Steel Corp., Chicago, Ill.
3. Bethlehem Steel Corp., Bethlehem, Pa.

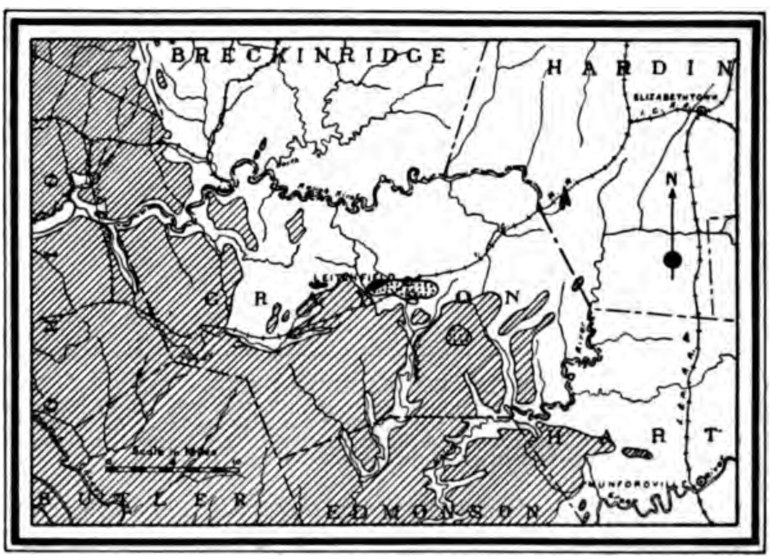
Manuscript completed *Dec.* **31, 1920.**

IX.

GEOLOGY OF OIL AND GAS IN GRAYSON COUNTY.

LOCATION.

Grayson county lies west of the Dixie Highway, in the west-central part of Kentucky, fifty miles or more west of south from Louisville, and a few miles northwest from Mammoth Cave. It is fifteen to twenty miles south of the Ohio river, from which it is separated by Ohio, Breckinridge, and Hardin counties. It is bounded on the east by Hardin and Hart counties on the south by Edmonson and Butler counties, and on the west by Butler and Ohio counties. Grayson county, the 54th in order of organization, was formed by legislative enact-



SKETCH MAP OF GRAYSON AND ADJOINING COUNTIES.

The hachured areas are Pottsville or Coal Measures of Pennsylvanian age. The white areas are the underlying Mississippian sandstones and limestones. Black areas indicate oil and dotted ones gas.

ment in 1810 from territory contributed by Ohio and Hardin counties.* It was named for a Colonel William Grayson of Virginia.

Field Work and Literature.

The date upon which this paper is based was secured by the writer personally in the field during a week's reconnoissance made partly in August, 1919, and partly in October, 1920. A number of widely separated wells were visited, and as much attention was given to stratigraphic and structural examinations as the limited time would permit. The writer was very greatly assisted in securing locational and recorded data

THE ED. WALLACE NO. 1 WELL.

This well is located one mile southwest of Leitchfield, on the Blowtown Pike. It is the property of the Kentucky Oil & Refining Co., and was drilled to a depth of 2,034 feet, January, 1918. The Major Sand was not recognized. Only shows of oil were secured.

concerning old drilled wells by many residents of the county, chief among who have been Mr. John E. Stone and Mr. W. B. Liles of Leitchfield. The Atlantic Oil Producing Co. has also given several records of wells it has drilled.

*Twelfth Biennial Report of the Bureau of Agriculture of Ky., 1897.

There is practically no detailed geologic literature of a distinctly oil and gas character relative to Grayson county. One geologic report* in touching the subject has condemned the entire county in a few casual words. Another more recent oil and gas book** considering Grayson county in its broader features only, regards commercial oil and gas as a distinct possibility. The old reports*** while making note of the presence of oil see pages in this part of Kentucky, omit any reference to oil and gas as a mineral resource of importance.

Drainage and Area.

Rough river and one of its tributaries, Meeting Creek, form the northern boundary of the county. Nolin river forms part of the eastern boundary. The southern part of the county through several streams drains directly into Green river, which flows through Edmonson county on the south. Grayson county contains 295,845 acres**** or about 460 square miles.

Culture.

Leitchfield, the county seat, a town of 1077 inhabitants, according to the 1920 census, is on the Illinois Central R. R., just east of the center of the county. It was named after Major David Leitch, who donated the town-site property. The railway extends in a northeast-southwest direction through the middle of the county. The roads of Grayson county radiate generally from Leitchfield, and are passable with an automobile, though rocky, during the dry weather. They are almost impassable during periods of prolonged wet weather.

Topography.

The surface of Grayson county is essentially that of a moderately uplifted plain or plateau. A few isolated knobs stand out as land marks, with maximum elevations of about 800 feet. Beneath these the ramifying ridge levels of the county spread

*J. O. Bryant, Ky. Geol. Survey, Series IV, Vol. II, Part I, pp. 212 and 218.

**W. R. Jillson, Dept. Geol. & For. of Ky., Series V, Bull. I, pp. 137, 138, 324.

***David Dale Owen, Kentucky Geol. Survey, Series I, Vol. I.

****Second Ann. Report Ky. State Tax Com., 1919.

out, in some localities broad and gently sloping, and in others narrow and steep, with scarcely enough room for the desirable ridge road. Some of the valleys are broad and shallow, exhibiting commonly in the northern part of the county many "sink holes" which are attended by imperfect drainage. In the extreme northern and extreme southern portions of Gray-

BLOWING THE W. S. PROCTOR NO. 1 GASSER.
This well produces about 1,000,000 cubic feet of wet natural gas and artesian water. It is located one mile south of Leitchfield, Grayson County, Ky., and is owned by the League Oil & Gas Co.

son the streams have chiseled out for themselves canyons upwards of 100 feet in depth, which although they impede transportation in these sections, add much to their scenic beauty. A general difference of relief of between 150 and 200 feet exists throughout the county. The exact elevations in feet above sea level of the following points, located on the Illinois Central R. R., have been established: Leitchfield, 635; Big Clifty, 682; Caneyville, 399; Spring Lick, 387; and Falls of Rough, 423.

STRATIGRAPHY.

An eastern prong of the western coal basin of Kentucky extends with its rocks of Pennsylvanian age through the

southern and south central part of the county. The northern part of the county exhibits almost entirely Mississippian or Lower Carboniferous strata. Several of the south flowing streams have cut their valleys through the Coal Measures (Pennsylvanian) into the underlying Mississippian, so that in the middle of the county one can go from the north to the south boundary of the county on Mississippian rocks by following the larger valleys. The total thickness of the Mississippian series in Grayson county is about 1350 feet, being 1329 feet in the Hazelwood well at Meredith post office, 1366 feet in the McGrew well at Anneta post office in southern Grayson, and 1355 feet in the Duncan well in western Grayson near the Ohio county line.

The Pennsylvanian Series consists of beds of sandstone, shale and clay, with here and there thin coal seams, all being included in the Lower Pottsville group. The thickness of the Pottsville varies with the amount of erosion, and ranges from thin remnants of a few feet up to about 400 feet. The Mississippian Series consists of numerous beds of limestone, sepa-

DICK'S TOBACCO BARN.
One of the natural curiosities of central Grayson County and dependent upon its geology is this magnificent cave at Pine Knob.

rated by beds of sandstone and shales. In general this series can be subdivided into formational units that can be correlated with the subdivision of the series that has been made in Indiana and Illinois to the north and northwest.

The upper half or so of the series, consisting of an alternating succession of predominately limestone and of sandstone formations are undoubtedly the continuation southward of the Huron-Chester-Kaskaskia beds of Indiana and Illinois. They are characterized by a great abundance of fossils including many genera and species of Bryozoa and many species of Pentremites and the genus Archimedes of the Bryozoa are the most distinctive fossils of the Chester group. Below the Chester group the St. Louis limestone, which is included in the Mitchell limestone of Indiana, outcrops in the county. The rocks below the St. Louis, including the Warsaw (Harrodsburg) and the still lower shales of the Osage ("Knobstone") group of Indiana, including the Rosewood shale and Kenwood sandstone (Keokuk) and the New Providence shale (Burlington), as well as the New Albany black shale, do not outcrop in the county, although all, with the possible exception of the Kenwood sandstone, underlie the outcropping formations. The Black (New Albany) has been penetrated in a number of places by the drill in the deeper borings.

STRUCTURE.

The most marked disturbance of the rocks in this region is an anticlinal uplift having a general east and west trend through the county. This structure, which has a figured height of from 150 to 350 feet, is faulted in the eastern part of the county, but is apparently intact for some distances in the western part. It is known as the Rough Creek or Rough River uplift and occurs near the areal contact of the Pennsylvanian or Mississippian series. On the north side of this uplift there are local folds and faults. Others* also occur on the south side, but principally at some distance from the main structure. The town of Leitchfield is located on the crest of this anticlinal uplift.

*Ky. Geol. Survey, Series IV, Vol. II, Part I, pp. 155-170.

One of the most pronounced faults observed in the area is one on Pine Knob Creek about one and a half miles north of Pine Knob post office where mining operations for zinc ore were carried on some years ago. This fault has a northeast-southwest trend, probably continuous with a fault on Short Creek about two miles south of Short Creek post office.

There is an anticlinal fold with some faulting along the axis, extending from a short distance north of Caneyville to about two miles south of Caneyville. A very distinct double doming anticline is also to be seen at Meredith and Annetta post offices, about seven miles southeast of Leitchfield. Other folds and faults occurring in small figure are found at various points in the county.

Oil and Gas Development.

Between thirty-five and forty wells have been drilled in Grayson county, in exploration for oil and gas. Elsewhere in this paper will be found all the information now available concerning thirty-two of these wells, including the deep R. O. Meredith test at Leitchfield now 2030 feet drilling. Four new locations within Grayson county are reported for spring of 1921 drilling.

One of the very early oil and gas wells, if indeed not the first, to be drilled in Grayson county was the "Old Leitchfield" well, which was drilled about 1890 near the county seat from which it took its name. It produced, according to the reports of various inhabitants of Leitchfield, between five and ten thousand cubic feet of gas, and was subsequently abandoned. The second test of Grayson county came about 1905-6, when W. B. Cosby drilled into small production near Millerstown on the Hart county line. Small amounts of tarry volatilized oil may still be taken from this old well.

Several gas and artesian water wells have been drilled near Leitchfield. The best gas well, known as the Xerxes Hunter No. 1, located at the northwest corporate limits of the town, is now capped. About 100,000 cubic feet of gas from this well is being used daily in Leitchfield. This Hunter well is reported to have had an initial flow of approximately four million cubic feet, but according to last measurements was pro-

DRILLING ON THE PROCTOR-WHITE TRACT.
This well is about one mile south of Leitchfield. The drilling was done by the League Oil & Gas Co.

ducing about 2,500,000 cubic feet daily. Of the everal other wells in the immediate vicinity, one at least, the W. S. Proctor, is a commercial gasser producing large quantities of artesian salt water, and the rest are uncommercial gassers or dry holes. About five million cubic feet of gas is now capped in Grayson

county, and except the small amount used at Leitchfield, none is being commercialized.

On the Wm. F. Major farm, some eight miles west of Leitchfield, three test wells were drilled in to small oil production by Carl Dresser in 1918. He followed these with one on the Muffitt farm, which was also a small oil producer Another was drilled about 3½ miles further north by Richards, et al. It showed very small oil and was abandoned.

A well drilled on the C. Hazelwood farm at Meredith post office on the top of the Meredith Dome, about seven miles southeast of Leitchfield, is reported to produce 2,000,000 cubic feet of gas. Another drilled on the James E. McGrew farm at Anneta, two miles further south on the Anneta Dome, showed oil just above the Black Shale (Devonian), and again at some distance below it, but was subsequently abandoned. A well on the Cook farm, six miles west of Leitchfield, is reported a dry hole. The same report is given of two wells on the Young farm on Short Creek, one three miles and one four and a half miles northwest of the Cook well.

A PICTURESQUE BROOKSIDE.

The natural beauty of the Pine Knob section of Grayson County is enhanced by a small stream that winds its way through rugged sylvan glades to join the Rough River at the north.

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The natural beauty of the Pine Knob section of Grayson County is enhanced by a small stream that winds its way through rugged sylvan glades to join the Rough River at the north.

A well was drilled south of Caneyville some considerable distance down flank on the south of the Rough Creek anticline, and was unproductive at about 900 feet deep. A complete log or report on this well has not proven available, and its total depth is not known.

A well drilled in the summer of 1918 in Hardin county, about six miles northwest of Big Clifty, is said to have struck oil, but nothing is known about its quantity or quality. In 1919, a well started on a low dome near Big Clifty, near the north boundary of the county, showed oil, but was completed as a dry hole and abandoned.

Besides these above noted wells, a number of other salt water or dry holes (uncommercial) have been drilled recently in Grayson county, on which data is not available. Prospective operators in this field are advised to thoroughly scout and accurately locate these wells on their county and structural maps before purchase of property in Grayson is entered into. This scout work is regarded at this period of the development of the oil and gas of the county as of great importance. It is especially important for the south side of the large Rough Creek uplift. While this structure undrilled now offers immense possibilities because of its size, as a completely tested and commercially unimportant structure it certainly would not be worth any oil operator's consideration beyond this absolute determination.

A small productive oil pool has been opened near Hartford in Ohio county, just west of Grayson, from which oil has been shipped in limited quantities for several years. The oil producing "sand" of this Ohio county pool is found below the Black Shale (Devonian).

ASPHALT.

Asphalt and asphaltic sandstone occur in considerable quantities in several places in Grayson county. They also are found in Edmonson county on the south, and in Breckinridge county to the north. The asphalt deposits have been worked to some extent in years past in the southern part of Grayson

county, and the northern part of Edmonson county.* Large operations are now established at Kyrock on the Nolin river in Edmonson county.** Still other asphaltic deposits have been worked at Tar Hill, a few miles west of Big Clifty, in the northern part of Grayson county.

Oil and Gas Sands.

In the development of any new or partially explored oil and gas field a fundamental problem of intense interest to all operators and geologists is the accurate establishment of the sequence of possibly productive "sands." The term "sands" is here used in the broad sense employed by the driller—an oil or gas producing strata—irrespective of its lithological constitution as a shale, limestone, or true sandstone. The accurate determination of the sequence of "sands" is of first importance, since without it is quite impossible to say whether any except a very deep well has tested any given locality.

The amount of development which has been carried forward to this date in the Grayson section has lead to the recognition of three certainly petroliferous horizons. The lowermost of these is undoubtedly Upper Ordovician, the middle one is quite certainly Silurian, and the upper "sand" is middle Lower Mississippian. Though occasionally petroliferous, asphaltic, and gassy, the sandstones of the Pennsylvanian System, stratigraphically the highest in the county, are not included in this enumeration, since their proximity to the surface renders them uncommercial. The commercial "sands" of the Grayson district in rising order of sedimentation are hereinbelow discussed in detail. Brief interlineations have also been added concerning other possibly productive horizons.

Ordovician: The R. O. Meredith No. 1 (2030 feet) at Leitchfield, and the Duncan No. 1 (2152 feet) in western Grayson county, have both found a deep thin sandy limestone in the upper Ordvician that is assuredly petroliferous and gassy, and also a container of salt water. The very considerable dis-

*See Ky. Geol. Survey, Series IV, Vol. II, Part I, p. 189

**See Paper No. II, Ky. Rock Asphalt—The Ideal Road Surface, pp. 39-57.

tance between the Duncan and the Meredith wells, and their absolute accordance not only in this sand but also in the Chattanooga or Ohio black (Devonian) shale and other higher horizons, is significant. This deep Ordovician "sand" in the

THE R. O. MEREDITH WELL.
It is being drilled one mile southeast of the Leitchfield Court House by the Cinoky Oil Company. On Mar. 1, 1921 this well had reached a depth of 2,030 feet.

Duncan well was six feet thick and was found at a depth of 425 feet below the base of the Devonian black shale. In the Meredith well it was three feet thick and was found 434 feet below the black shale. So far as is known, no other wells in Grayson have pierced this sand, the deep Hazelwood and Dunn wells having finished above it several hundred feet.

Silurian: An oil and gas horizon of some considerable importance for all wells located on definite structures is that which has been recognized by the C. Hazelwood No. 1 (1910 feet) at Meredith post office, and the John T. Dunn No. 1 (1508 feet) at Leitchfield. This "sand" is reported as a sandy limestone, grayish brown in color, 15 feet thick in the Hazelwood and 10 feet deep in the Dunn well. In the Hazelwood well the top of it occurs 107 feet below the base of the Black (Devonian) shale, and in the Dunn well it is found 215 feet below

the base of the same shale formation. The record of the Hazelwood well reports the last 70 feet, a gray white limestone, and to have contained oil and salt water. The 30 feet of sand reported at 1740 feet in the Duncan well (western Grayson county) is found at 185 feet below the base of the Black shale (Devonian), and though non-petroliferous, is evidently the same horizon.

Mississippian: Passing the Devonian limestone, which lies immediately below the Black shale, and is quite petroliferous in Ohio county to the west and exceedingly so in many another county in Kentucky, as unproductive, due to the fact that in all the wells drilled in this section it is either absolutely dry or gives only a trace, the next and the most important oil horizon in Grayson county is found in the Mississippian series above the Black Shale (Devonian). Practically all of the wells drilled to the Black Shae show a ten to fifteen foot sandy, cherty or flinty limestone directly above and lying upon the Black Shale. In some wells, as the R. O. Meredith (2030 feet) at Leitchfield, and the James E. McGrew (2185 feet) at Anneta, from twenty to thirty feet of sandy limestone is found containing some oil and

ENTRANCE TO BIG MOUTH CAVE.

The caves of Pine Knob have long been the mecca of the curious. Situated on the top of the Rough Creek uplift, they also have interest for the structural geologist and oil operator.

gas at points ranging from 30 to 100 feet above the top of the Black Shale. While not markedly petroliferous in such wells as have already been drilled, this "sand" will bear close watching, and should on good structural locations always be drilled through, as its stratigraphic position close above the Black Shale (Devonian) gives it immense petroleum producing potentialities.

The oil sand of principal interest at this period in the development of the county, due to its apparent near commercialization, is that which is known as the "Major sand," so named because of the successful exploration of it by Carl K. Dresser on the Wm. F. Major farm about six miles west of Leitchfield. On the Major farm where it was first drilled to considerable oil production, it occurs about 400 feet below the surface. At Leitchfield it is about 800 feet deep, at Meredith post office 1150 feet, and in the western part of Grayson county near the Duncan well it is about 850 feet deep. The Major sand is definitely recognizable in the Duncan, Hazelwood, Muffit, Major, R. O. Meredith, Mary L. Hill, and probably a few other wells where the records have been carefully kept. It is a sandy limestone, somewhat porous, from fifteen to fifty-five feet in thickness. It occurs in the lower Mississippian series about from 400 to 500 feet above the Black Shale (Devonian), and from 400 to 600 feet below the well known and easily recognizable Big Clifty sandstone of the upper Mississippian. Excepting along the very top of the Rough Creek anticline, where it has in some places been eroded, the Big Clifty sandstone, 50 to 60 feet thick, forms the best drilling marker from which to calculate the probable depth to the Major sand.

Analyses and Well Logs.

Herewith are appended two oil analyses and a number of revised well logs of Grayson county.

ANALYSIS NO. 1.

Laboratory No. G-3855.—Petroleum, labeled "Green oil from the Major wells, west of Lietchfield, Grayson County, Ky., Carl Dresser, operator. Collected by W. R. Jillson, August 26, 1919, from open tank, oil had been in storage some time. Oil horizon a Waverly 'stray sand.'"

Sample, a rather thin, slightly greenish oil, dark brown by transmitted light.

Specific gravity at 60° F., 0.8785, equivalent to 29.4° Baume.

Distilled below 150° and 300° C. (302° F.)	7.4%	(Gasoline fraction)
Distilled bet. 150° and 300° C. (302-572° F)	33.5%	(Burning oil fraction)
Tarry residue	59.0%	
Total	99.9%	

Began to distill at 85° C. (185° F.)

Analysis by A. M. Peter, Chief Chemist.
Lexington, Ky., Sept. 4, 1919.

ANALYSIS NO. 2.

Laboratory No. G-3854.—Petroleum, labeled "Green oil from S. R. Moffitt well, west of Leitchfield, Grayson County, Ky., Carl Dresser, lessee. Collected by W. R. Jillson, August 26, 1919. Oil horizon a Waverly 'stray sand.'" Sample, a thick, slightly greenish oil, very dark brown by transmitted light. Oil had been in storage some time.

Specific gravity at 60° F., 0.870, equivalent to 30.9° Baume.

Distilled below 150° C. (302° F)	3.8%	(Gasoline fraction)
Distilled bet. 150° and 300° C. (302-572° F)	34.5%	(Burning oil fraction)
Heavy, tarry residue	61.5%	
	99.8%	

Began to distill at 116° C. (241° F.)

Analysis by A. M. Peter, Chief Chemist.
Lexington, Ky., September 4, 1919.

Both of the above samples—the best that could be secured at the time—were taken from open tanks and had been standing for some time. Reasonably the oil in the tanks had volatilized considerably. Fresh samples from the Major sand may therefore be expected with confidence to show a much lighter character, higher Baume gravity, and increased gasoline fraction. Grayson county oils from this sand are probably of Somerset grade.

GRAYSON COUNTY WELL RECORDS.

Log No. 1.

Ed. F. Wallace, No. 1, lessor.
Kentucky Oil and Refining Co., lessee.
Location—Near Leitchfield, Kentucky.
Begun October 10, 1917.

Completed January 4, 1918.
Elevation 592 feet.
Reported production, dry?

Strata	Thickness	Depth
MISSISSIPPIAN SYSTEM.		
Clay, soil	10	10
Limestone	18	28
Blue marl or clay	22	50
Limestone	40	90
Sand, courthouse	20	110
Limestone, Kaskaskia	55	165
Sand, Big Clifty, first water 190	55	220
Shale and limestone shells	9	229
Blue shale or marl	10	239
Limestone, blue	9	248
Blue shale or marl	13	261
Limestone brown	16	277
Blue shale	1	278
Sandy limestone, somewhat whitish	6	284
Blue shale	1	285
Limestone	190	475
Limestone, brownish	28	503
Limestone, gray	32	535
Limestone, nearly white	19	554
Limestone, brown sulphur water at 580	46	600
Limestone, brownish gray sandy	32	632
Limestone, light brown	18	650
Limestone, dark brown	50	700
Limestone, dark gray for last 5 feet	45	745
Limestone, dark gray	55	800
Limestone, gray with white specks	27	827
Limestone, black or dark brown	40	867
Limestone, brown a few white specks	18	885
Limestone, dark gray top 15 ft. brown	140	1025
Limestone, gray, soft	55	1080
Limestone, gray, soft	15	1095
Limestone, gray, sandy, few white specks	5	1100
Limestone, brown, hard	40	1140
Limestone, gray rather hard	13	1153
Limestone, brownish	107	1260
Limestone, sandy specks	36	1296
DEVONIAN SYSTEM.		
Shale, black (Chattanooga)	160	1456
Limestone, very dark	14	1470

Strata	Thickness	Depth
Limestone, gray white flakes	4	1474
Limestone, dark, soft	5	1479
Limestone, gray light flakes	52	1531
Limestone, dark soft (place 1st Ohio oil)	9	1540
Limestone, gray medium, some white flakes	6	1546
Limestone, light gray, some white flakes	43	1589
Limestone, light gray harder	15	1604
Limestone (white, little gas 1609)	17	1621
Limestone, darker, browner, softer	16	1637
Place for second Ohio sand.		
Limestone, brownish gray white flakes	13	1650
Limestone, dark, rather hard, sandy	32	1682
Limestone, dark pitted spots	4	1686
Limestone, lighter	14	1700
Limestone, light, softer mottled	16	1716
Limestone, light, harder	14	1730
Limestone, lighter, softer	50	1780
Limestone, little pocket gas	60	1840
Limestone, little harder	10	1850
Limestone, sulphur, salt water	15	1865
Limestone, light, last 5 ft. very hard	30	1895
Limestone, light, hard	5	1900
Limestone, very dark, soft	15	1915
Limestone, gray	22	1937
Limestone, light brown	28	1965
Limestone, gray	47	2012
Limestone, light brown, sandy	22	2034
Total depth		2034

Cased November 1, 1917, at 800 feet.
One foot of lime pyrites in Devonian Shale at 1424.
James H. Hancock, driller.

Note: The places as indicated for the 1st and 2nd Ohio oil sands are notes of the driller. The Devonian, Silurian and Ordovician sediments are not differentiated in the lower record of this well.

Log No. 2.

Xerxes Hunter No. 1.
Kentucky Oil and Refining Co., lessee.
Location—Southern limit of Leitchfield.
Started May 14, 1917.
Finished August 22, 1917.
Elevation 618 feet.
Production, 2,500,000 cu. ft. gas.

Strata	Thickness	Depth
MISSISSIPPIAN SYSTEM.		
Shale, sand and clay	32	32
Limestone (Chester No. 2)	40	72
Shale or marl	28	100
Limestone, Kaskaskia (Chester No. 1)	35	135
Clay, blue	20	155
Sand, Big Clifty (base of Chester)	40	195
Limestone (St. Louis or St. Genevieve)	20	215
Clay or mud	10	225
Limestone	37	262
Clay or mud	13	275
Limestone, gray, sulphur water at 459 and 540	295	570
Limestone, light brown, more water	45	615
Limestone, gray soft, for 10 feet	75	690
Limestone, dark brown, hard	75	765
Limestone, dark, more sulphur	50	815
Limestone, black, cased at 840, trace gas at 900	136	951
Limestone, black	9	960
Limestone, sandy nearly black, 2,000,000 cu. ft. gas	4	964

Drillers Note: According to this log shale or marl for 28 feet seems to have taken the place of the Leitchfield sandstone which lies between the Kaskaskia and Lime No. 2 of the Chester, although at the quarry about 250 feet north of the well, Lime No. 2 lies above said Leitchfield Flag, with perhaps a clay parting between them. We find this Leitchfield Flag, or sand No. 2 (Courthouse sand) between said two limestones, in the Allen-Wallace well, about 1,000 feet southwest of this well.

Last casing was set at 840 feet.
Longfellow and Barton drilled in.
Morrison, chief driller.

Note: This is a very condensed record of this well, many of the screws sampled separately being taken as one strata. This well all in the Mississippian. The gas sand may be regarded as the Major but it is actually about 125 feet below the place where the Major sand should be.

Log No. 3.

Mary L. Hill, No. 1, lessor.
Grayson Oil & Gas Co., lessee.
Location—Near Leitchfield.
Begun May 4, 1917.
Finished July 19, 1917.
Elevation, 665 feet.
Production, oil show.

Strata	Thickness	Depth
MISSISSIPPIAN SYSTEM.		
Soil and clay	12	12
Sand No. 2	18	30
Limestone, Kaskaskia	50	80
Sand, Big Clifty	80	160
Shale, water	12	172
Limestone, St. Louis, gas at 320	188	360
Limestone (St. Louis)	100	460
Limestone, dark brown, top of blue lick	20	480
Limestone, sandy gray	15	495
Limestone, brown, blue lick water 505	50	545
Limestone, sandy gray	15	560
Limestone, gray	184	744
Limestone, white and brown mixed	16	760
Limestone, brown sandy gritty (cased here)	2	762
Limestone, dark gray	4	766
Limestone, dark gray, show of oil (Major sand)	47	813
Limestone, dark gray	6	819
Limestone, black	56	875
Limestone, dark, gray, sandy, little gas	22	897
Limestone, dark gray	48	945
Limestone, black, mixed with shale	255	1200
Limestone, black, mixed with shale	13	1213
DEVONIAN SYSTEM.		
Shale, black (Chattanooga)	137	1350
Limestone, gray and white mixed	15	1365
Limestone, white and brown mixed	66	1431
Limestone, dark brown, little gas (1st Ohio sand)	2	1433
Limestone, dark brown	12	1445
Limestone, gray and white	36	1481
Limestone, light gray	29	1510

Strata	Thickness	Depth
Sandy limestone, oil, gray (2nd Ohio sand)	14	1524
Limestone, hard, light gray	18	1542
Limestone, white	15	1557
imestone, brown	5	1562
imestone, white	6	1568
Limestone, brownish gray	22	1594
Limestone, brownish gray, hard gritty	3	1597
Sandy limestone, brownish gray	6	1603
Sandy limestone, grayer	5	1608
Limestone, gray, shelly	10	1618
Limestone, dark gray, hard	15	1633
Limestone, dark, hard	20	1653
Limestone, gritty, hard	7	1660

Shot at 1522 feet on July 9, 1917.
Longfellow, Morrison & Gettings, Drillers.

This well probably finished in the Ordovician. The Devonian-Silurian and SilurianOrdovician contacts were not noted.

Log No. 4.

Carl Hazelwood, No. 1, lessor.
Kentucky Oil & Refining Co., lessee.
Location—6-7 miles southeast of Leitchfield at Meredith P. O.
Well drilled in 1917.
Elevation estimated at 755 feet above sea level.
Production, 200,000 cu. ft. gas—oil traces.

PENNSYLVANIAN SYSTEM.

Soil and clay	10	10
Shale, gray, soft	28	38
Sand, gray	5	43
Shale, black, soft	32	75
Sand, black (asphaltic)	5	80
Shale, black	25	105
Sand rock	5	110
Shale, black	40	150
Coal	1	151
Shale, black	5	156
Sand, gray	10	166
Sand (asphaltic)	25	191
Shale	2	193
Sand, gray	13	206
Shale, gray	63	269

	Thickness	Depth
[SYSTEM.		
brown, hard	10	279
ırl, gray, red and blue	27	306
gray, hard	10	316
	4	320
gray, Kaskaskia	46	366
gray	46	412
gray to dark gray, Kaskaskia	33	445
	5	450
soft, Big Clifty (Chester		
	60	510
gray, hard	92	602
	3	605
brown and gray, sandy	223	828
white, fine grained, sandy	37	865
cased at 908, little gas 940	130	995
vn	10	1005
brown and white	140	1145
ınd gray sand (Major sand)		
e gas	15	1160
gray, hard	35	1195
	12	1207
ınd shale mixed and sandy		
ıe	38	1245
medium soft	20	1265
dark gray and black, hard		
	155	1420
ınd shale, some flinty rock		
feet	176	1598
STEM.		
or brown (Chattanooga)	120	1718
black, gray and brown	107	1825
grayish brown, sandy (small		
	15	1840
graywhite, oil and salt water	70	1910
epth		1910

Crary, Chief Driller.

ıson, No. 1, lessor.
y, lessee.
ear Leitchfield.
ıary 18, 1917.
ril 26, 1917.
)0 feet.
small oil.

Strata	Thickness	Depth
MISSISSIPPIAN SYSTEM.		
Soil and clay	12	12
Limestone, hard	12	24
Crevice, no cutting	14	38
Limestone, dark, gritty	12	50
Limestone, dark, soft	5	55
Limestone, gritty, soft	5	60
Limestone, dark, gritty, hard	10	70
Limestone, gritty, hard	3	73
Limestone, dark	12	85
Limestone, gray, hard	15	100
Limestone, light, soft	5	105
Limestone, light brown, hard	10	115
Limestone, yellow, hard	12	127
Limestone, white, hard	3	130
Limestone, dark, hard	10	140
Limestone, yellow, hard	10	150
Limestone, gray, soft, gritty	10	160
Limestone, gray, hard	5	165
Limestone, fire clay	2	167
Limestone, gray, hard, gritty	21	188
Limestone, dark, soft (sulphur at 200)	27	215
Limestone, dark, hard	15	230
Shale, gray	5	235
Limestone, dark, hard	5	240
Limestone, gray	5	245
Shale, gray and slick	40	285
Shale and limestone, gray, soft	10	295
Shale and limestone, black	20	315
Limestone, black, blue lick	18	333
Limestone, dark, hard	31	364
Limestone, dark, soft, casing at 368	21	385
Limestone, dark, gritty, water	10	395
Limestone, gray, soft, recased at 410	15	410
Limestone, dark gray	10	420
Limestone, gray, hard	20	440
Limestone, dark, hard	20	460
Limestone, dark, shaly imestone	40	500
Limestone, gray, medium hard	45	545
Limestone, dark, hard	55	600
Limestone, dark, brownish, hard	25	625
Limestone, dark, soft	20	645
Limestone, dark, hard	15	660
Limestone, gray, soft	140	800
Limestone, dark, shelly	35	835

Strata	Thickness	Depth
Limestone, dark, shelly, hard	5	840
Limestone, gritty, sandy gray, hard	7	847
Limestone, dark, soft	48	895
Limestone, dark, soft, gritty(Beaver) "sand")	15	910
DEVONIAN SYSTEM.		
Shale, black Chattanooga)	126	1036
Limestone and shale mixed	7	1043
Shale, black Chattanooga)	5	1048
Limestone, white and some shale	5	1053
Limestone, nearly white, hard	4	1057
Limestone, gray, hard	8	1065
Limestone, gray, shaly	5	1070
Limestone, gray, soft	5	1075
Limestone, gray with white flakes	10	1085
Limestone, dark, with flakes	5	1090
Limestone, dark, hard	7	1097
Limestone, somewhat lighter, sandy	4	1101
Limestone, dark, brownish, hard	3	1104
Limestone, light gray, hard	12	1116
Limestone, darker, soft, shale (1st oil)	5	1121
Limestone, brownish, medium hard	3	1124
Limestone, gray, hard	13	1137
Limestone, brown, hard	6	1143
Limestone, lighter, medium hard	7	1150
Limestone, dark brown, hard	8	1158
Limestone, gray, hard	5	1163
Limestone, gray, medium hard	8	1171
Limestone, gray, very hard	5	1176
Limestone, nearly white, very hard	34	1210
Limestone, dark, gritty (2nd oil)	23	1233
Limestone, dark brownish, hard	17	1250
Total depth		1250

Authority—A. H. Morrison, Driller.

The Devonian-Silurian contact is not noted. Well probably finished in Silurian.

Log No. 6.

James E. McGrew, No. 1, lessor.
Kentucky Oil & Refining Co., lessee.
Location—Anneta Post Office
Started December 30, 1916.
Finished April 25, 1917.
Elevation 750 feet, estimated.
Production, oil show. Abandoned.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM.		
Soil and clay	8	8
Sand rock	3	11
Shale, gray	5	16
Sandstone, black (asphaltic)	1	17
Shale, blue	70	87
Sand, trace of asphalt	40	127
Shale, blue	28	155
Shale, light gray	17	172
Shale, blue	18	190
MISSISSIPPIAN SYSTEM.		
Limestone and shale, water	10	200
Shale, white	5	205
Marl, red and blue	8	213
Shale, white	7	220
Shale, blue	30	250
Limestone shells	5	255
Shale, blue	48	303
Limestone, white	8	311
Shale, blue	15	326
Limestone, gray, very hard	32	358
Shale	10	368
Sand	45	413
Limestone, hard, Kaskaskia	35	448
Shale	8	456
Sand (Big Clifty)	42	498
Shale, blue, soft	12	510
Limestone, gray, moderately hard	5	515
Shale, gray, hard	5	520
Limestone, white, hard	10	530
Shale, white, hard	4	534
Limestone, soft streaks (540-550)	40	574
Shale, tough, hard, white	10	584
Limestone, varying color and hardness	156	740
Limestone, gray, sandy, Blue Lick at 830	150	890
Limestone, white, soft, no grit	25	915
Limestone, hard, flinty, gritty, cased at 918	7	922
Limestone, brown and white, soft	60	982
Limestone, dark gray, mixed white	18	1000
Limestone, brown and white	40	1040
Limestone, dark gray, hard	30	1070
Limestone, dark, brown, hard	65	1135
Limestone, black	9	1144

Strata	Thickness	Depth
Limestone, brown and gray shales	23	1167
Limestone, gray	35	1202
Limestone and shale mixed	70	1272
Shale, sandy, dark	3	1275
Shale, sandy, light gray	15	1290
Limestone, gray, very hard, small gas 1355	65	1355
Limestone, black, hard	45	1400
Limestone, gray, soft, shelly	10	1410
Limestone, gray and mixed with sand	5	1415
Limestone, white, sandy (Beaver "sand")	70	1485
Shale, dove color, soft with hard shells of gray limestone	35	1520
Sand, gray and lime, show of oil at 1523, gas at 1531	19	1539
Shale, green and soft	17	1556

DEVONIAN SYSTEM.

Strata	Thickness	Depth
Shale, brown (Chattanooga)	110	1666
Limestone, dark, hard, gray	25	1691
Limestone, white and gray mixed	10	1701
Limestone, dark brown	15	1716
Limestone, gray	5	1721
Limestone, light gray, oil trace, very hard	34	1755
Limestone, brown, very hard	15	1770
Limestone, gray, soft, white flaked	25	1795
Limestone, white, hard	35	1830
Limestone, gray, oil trace, little salt water	5	1835
Limestone, white	25	1860
Sand, gray, show of oil, stopped on hard shell, strong flow of salt water	5	1865
Sand, hard, white	10	1875
Limestone, gray, mixed with shale	25	1900
Limestone, brown, moderately shoft, 1100 feet of water in well	10	1910
Limestone, brown	15	1925
Limestone, gray, very hard	5	1930
Limestone, dark gray	5	1935
Limestone, white, hard	15	1950
Limestone, gray and white	35	1985
Limestone, gray shale and lime mixed	5	1990
Limestone, dark gray, changing to light gray	30	2020

Strata	Thickness	Depth
Limestone, blue gray	10	2030
Limestone, light brown	55	2085
Shale, light gray	50	2135
Limestone, gray	25	2160
Shale, blue gray	10	2170
Limestone and gray shale in thin bed	15	2185
Total depth		2185

The Devonian-Silurian contact and the Silurian-Ordovician contact is not noted. The well finished in the Ordovician. This is one of the very few wells in Grayson County showing a trace of oil in the Devonian limestone. Since the well was located on the top of the Anneta Dome and did not produce from the Corniferous or its correlative there would seem to be little hope for this "sand" in other wells less favorably located.

Log No. 7.

John T. Dunn, No. 1, lessor.
C. H Dooley, lessee.
Location—Leitchfield.
Started February 8, 1918.
Finished April 29, 1918.
Production, small oil.

MISSISSIPPIAN SYSTEM.

Clay	39	39
Limestone	4	43
Shale or marl, 14" conductor to 42 ft	30	73
Sand (Big Clifty)	58	131
Cave, no cuttings	5	136
Limestone, St. Louis, St. Genevieve	29	165
Shale	20	185
Sand	15	200
Limestone, St. Louis	50	250
Shale, slick	8	258
Limestone, gray	70	328
Limestone	52	380
Shale	4	384
Limestone, gray, cased 8" at 386	31	415
Limestone, brown	50	465
Limestone, gray, brown flakes	12	477
Limestone, brown	10	487
Limestone, brown, sulphur water	5	492
Limestone, gray, soft	5	497

Strata	Thickness	Depth
Limestone, brown some, hard	13	510
Limestone, brown, hard	15	525
Limestone, gray, soft	5	530
Limestone, brownish, soft and hard	20	550
Limestone, gray, softer and medium	10	560
Limestone, dark brown, harder	11	571
Limestone, dark gray, white specks, soft	7	578
Limestone, brown, hard	5	583
Limestone, gray, softer, sulphur at 585..	4	587
Limestone, brown	18	605
Limestone, very dark, oily, coffee grounds	5	610
Limestone, dark gray, cased 6" at 616	17	627
Limestone, brown and gray	55	682
Limestone, dark gray, white specks	23	705
Limestone, dark black, sulphur water	3	708
Limestone, dark gray, white specks	4	712
Limestone, sandy, oily	41	753
Limestone, softer, cased at 758	5	758
Limestone, dark gray, some chert and hard streaks	370	1128
Limestone, sandy specks (Beaver "sand"?)	15	1143

DEVONIAN SYSTEM.

Strata	Thickness	Depth
Shale, black, Chattanooga or Ohio	137	1280
Limestone, gray, last screw sandy	38	1318
Limestone, gray	15	1333
Limestone, dark brownish gray	6	1339
Limestone, gray	13	1352
Limestone, sandy gray (place 1st Ohio oil)	8	1360
Limestone, dark gray, soft flakes	14	1374
Limestone, gritty, light specks	94	1468
Limestone, gray, nearly white	5	1473
Limestone, shade darker	6	1479
Limestone, gray, shade lighter	16	1495
Limestone, sandy, oil sand, little oil	10	1505
Limestone, nearly white	3	1508
Total depth		1508

Water at 165 and 10" casing to 158 feet.

Authority—James Hancock, Driller.

The Devonian-Silurian contact is not noted. This well probably finished in the Silurian.

Log No. 8.

Emma J. Tucker, No. 1, lessor.
Brady Oil & Gas Company, Emporium, Pa., lessee.
Location—2 miles northeast of Leitchfield.
Started August 17, 1918.
Production, dry. Abandoned.

Strata	Thickness	Depth
MISSISSIPPIAN SYSTEM.		
Soil, clay, etc.	14	14
Sand (Big Clifty)	70	84
Unrecorded	6	90
Limestone, gray	10	100
Limestone, brown	5	105
Unrecorded	3	108
Limestone, gray	36	144
Limestone, brown, sandy	35	179
Limestone, gray	10	189
Limestone, brownish	117	306
Shale or shaly	4	310
Limestone, gray, brown	74	384
Mud	2	386
Limestone, gray, brownish	31	417
Unrecorded	41	458
Limestone, light brown	24	482
Limestone, gray, brownish	110	592
Limestone, dark, brown	8	600
Samples missing, cases last time	151	751
Limestone, light gray, hard	14	765
Limestone, light gray, medium	35	800
Limestone, light gray, hard	26	826
Limestone, light dark, soft	10	836
Limestone, light dark, hard	14	850
Limestone, gray, hard	20	870
Limestone, dark, medium	14	884
Limestone, dark, hard	91	975
Limestone, dark, medium hard	35	1010
Limestone, dark, medium soft	55	1065
Limestone, dark, medium hard	122	1187
Limestone, brown sandy, oil	10	1197
Limestone, brown sandy, oil	8	1205
Limestone, shelly	4	1209
Limestone, black	29	1238
Limestone, gray, white specks	6	1244
Limestone, light gray, brown	56	1300
Limestone, black, sandy	8	1308

Strata	Thickness	Depth
DEVONIAN SYSTEM.		
Shale, black (Chattanooga)	112	1420
Limestone, shaly, dark	10	1430
Limestone, gray with white specks	15	1445
Limestone, dark	45	1490
Limestone, brownish gray	82	1572
SILURIAN SYSTEM.		
Limestone, bluish	52	1624
Total depth		1624

Authority—James Ross, Driller.

Log No. 9.

——— Duncan, No. 1, lessor.
Snowden Brothers, lessees.
Location—20 miles west of Leitchfield.

Strata	Thickness	Depth
MISSISSIPPIAN SYSTEM.		
Soil, sandy, yellow, soft	30	30
Shale, dark, gray, soft	55	85
Limestone, gray, hard	10	95
Limestone, white, softer	30	125
Shale, dark gray, very soft	35	160
Sandy shells, light gray	5	165
Soft shale, gray	73	238
Shale, gray	10	248
Limestone, brown, hard	20	268
Shale, limestone, light gray	15	283
Sand, gray (trace of oil)	10	293
Shale, brown	7	300
Limestone, white	60	360
Shale, gray	5	365
Shale, brown	15	380
Sand, gray, soft, fine (trace of oil)	35	415
Shale, dark gray	8	423
Limestone, dark	8	431
Shale, dark	10	441
Shale and shells, gray	24	465
Limestone, white, close	15	480
Sand, brown, coarse	5	485
Shale, gray	5	490
Limestone, light gray	130	620
Limestone, light brown	5	625

Strata	Thickness	Depth
Limestone, light gray	30	655
Limestone, gray, hard (Blue Lick 700)	95	750
Limestone, light brown	20	770
Limestone, brown, very hard	15	785
Sandy limestone, gray, very hard	20	805
Limestone, gray (casing at 815)	27	832
Limestone, brown	15	847
Limestone and shale, dark gray	13	860
Limestone, gray and brown, sandy, soft Major sand)	55	915
Limestone, gray, hard	165	1080
Limestone, black	25	1105
Limestone, gray, hard	15	1120
Limestone and shale, dark, soft	5	1125
Limestone, dark, hard	80	1205
Limestone, white and black mixed	20	1225
Limestone, white, sandy	15	1240
Limestone, gray	35	1275
Limestone, brown and white	45	1320
Shale and limestone, gray, soft	35	1355

DEVONIAN SYSTEM.

Strata	Thickness	Depth
Shale, black (Chattanooga)	200	1555
Limestone, brown	40	1595
Limestone, brown, very hard	40	1635
Limestone, dark brown, softer	35	1670
Limestone, red brown	25	1695
Limestone, changing to lighter	30	1725
Limestone, gray, very hard	15	1740
Sand, white, very hard	30	1770
Limestone, light brown, hard	45	1815
Limestone, light brown, sandy	85	1900
Limestone, white, hard	60	1960
Limestone, dark gray	20	1980
Limestone, yellowish gray, soft (trace of oil)	6	1986
Limestone, gray, hard	30	2016
Limestone, white	50	2066
Limestone, white, soft	5	2071
Limestone, gray, hard	80	2151
Limestone, white and soft, bottom, salt water	1	2152
Total depth		2152

The bases of the Devonian and Silurian are undifferentiated. This well probably finished in the Ordovician.

Log. No. 10.

Muffett, No. 1, lessor.
Atlantic Oil Producing Co., lessee.
Location—About 6 miles west of Leitchfield.
Strated July 29, 1918.
Finished April —, 1919.
Production, 5 barrels of oil.

Strata	Thickness	Depth
MISSISSIPPIAN SYSTEM.		
Red Clay	30	30
Limestone, white	100	130
Limestone, gray (143-145)	15	145
Limestone, soft, water	5	150
Limestone, white, hard	40	190
Limestone, black	125	315
Limestone, white, sandy (shells)	30	345
Limestone, black, hard	17	362
Limestone, grayish-white, sandy (water 362-372)	23	385
Limestone, black, hard	27	412
Limestone, gray	15	427
Limestone, black (gas at 437)	20	447
Limestone, white, very hard (little oil at 452, 499, 504)	56½	503½
Sand, nice show of oil (Major sand)	19½	523
Break in sand, limestone, gray, and shale	1	524
Limestone, gray, coarse	12	536
Limestone, gray, fine	4	540
Sand, brownish gray, (show of oil)	4	544
Limestone, gray (little blue shale)	11	555
Limestone, gray (more blue shale)	20	575
Shale, blue	15	590
Limestone and shells	10	600
Total depth		600

Authority—Claude E. Stanley, Manager.

Log No. 11.

R. O. Meredith, lessor, No. 1.
Cin. & Ky. Oil and Gas Co., lessee.
Location—Near Leitchfield, Ky.
Started July, 1920.
Still drilling February 10, 1921.
Elevation, about 630 feet.

Strata	Thickness	Depth
MISSISSIPPIAN SYSTEM.		
Clay	12	12
Limestone, white, hard	27	39
Shale, gray	36	75
Sand, little water	5	80
Limestone, white, hard	32	112
Shale and mud	23	135
Sand, Big Clifty	50	185
Limestone, white (St. Louis?)	200	385
Limestone, gray, gritty	65	450
Limestone, white, hard	60	510
Limestone, brown, hard	160	670
Blue Lick formation	103	773
Limestone, brown, hard	18	791
Sand, brown and limestone (Major sand)	30	821
Limestone, gray, gritty, hard	5	826
Limeston, brown, sandy	6	832
Limestone, brown	5	837
Limestone, dark gray	40	877
Limestone, gray	25	902
Limestone, dark gray	12	914
Limestone, light gray	12	926
Limestone, gray, gritty	28	954
Limestone, black, hard	20	974
Limestone, gray	7	981
Limestone, black, hard	11	992
Limestone, black, soft	152	1144
Limestone, dark gray	7	1151
Limestone, black, soft	79	1230
Sand, white.. } Oil sand?	7	1237
Sand, light.... }	15	1252
Shale and white limestone	6	1258
Limestone, black	18	1270
Sand, white	10	1280
DEVONIAN SYSTEM.		
Shale, brown	160	1440
Limestone, brown	25	1465
Limestone, brown and gray	9	1474
Limestone, gray, hard, gritty	6	1480

Strata	Thickness	Depth
SILURIAN SYSTEM.*		
Limestone, black and white	7	1487
Limestone, white, hard, gritty	13	1500
Limestone, brown, sandy	4	1504
Limestone, gray, gritty, hard	9	1513
Limestone, brown	5	1518
Limestone, dark gray, hard	23	1541
Limestone, black	9	1550
Limestone, gray	20	1570
Limestone, dark gray, hard	30	1600
Limestone, black and gray	12	1612
Limestone, gray, gritty, hard	6	1618
Limestone, gray and brown, sandy	15	1633
Limestone, white	11	1644
ORDOVICIAN SYSTEM.		
Limestone, brown and gray	40	1684
Limestone, brown, hard	12	1696
Limestone, brown and gray, gritty	5	1701
Limestone, white and brown	22	1723
Limestone, brown and gray, gritty	18	1741
Sandstone (water)	3	1744
Limestone, gray	6	1750
Limestone, white	35	1785
Limestone, gray, hard	21	1806
Limestone, blue	8	1814
Limestone, white	53	1867
Limestone, white, little black sulphur water	7	1874
Limestone, white, large salt water, oil and gas show	3	1877
Limestone, white	85	1962
Limestone, blue, soft	17	1979
Well incomplete (Feb. 19, 1921) at		1979

Note: Suspended for casing, Oct. 8, 1920. Machine broke down January 18, 1921, and again February 9, 1921.

*The actual thickness of the Silurian series in Grayson County is unknown, as the rocks of this division do not come to the surface in outcrop. A thickness of about 200 feet is assigned, however, based on nearest outcrop. This may be more or less.—W. R. J.

Log No. 12.

Wm. F. Majors, No. 1, lessor.
Carl K. Dresser, lessee.
Location—8 miles west of Leitchfield.
Started drilling June 21, 1917.

Strata	Thickness	Depth
MISSISSIPPIAN SYSTEM.		
Soil, red	10	10
Limestone, gray	10	20
Limestone, white	10	30
Limestone, yellow	15	45
Limestone, gray	15	60
Limestone, sandy, water	20	80
Sand	5	85(?)
Limestone, blue	15	100
Limestone, sandy, water	90	190
Limestone, black	60	250
Limestone, gray	100	350
Limestone, sandy	10	360
Limestone, dark (oil 360-380)	25	385
Limestone, gray	50	435
Limestone, brown	65	500
Limestone, white	10	510
Sand	10	520
Limestone, gray	20	540
Total depth		540

Authority: Mr. Stanley, Field Mgr.

Log No. 13.

Wm. F. Majors, No. 2, lessor.
Carl K. Dresser, lessee.
Location—8 miles west of Leitchfield.

MISSISSIPPIAN SYSTEM.		
Clay	50	50
Limestone, blue	70	120
Limestone, gray	20	140
Limestone, dark	70	210
Limestone, gray	80	290
Limestone, shaly	15	305
Limestone, dark	15	320
Limestone, gray	10	330
Limestone, black	10	340

Strata	Thickness	Depth
Limestone, gray	10	350
Sand	20	370
Limestone, black and gray	100	470
Limestone, black (show of oil at 508)	45	515
Limestone, light gray	22	537
Sand	7	544
Limestone, sandy	36	580
Limestone, gray	55	635
Shale, black	125	760
Limestone?	87	847
Total depth		847

Shot at 508 and 520 on December 6th, 1920.
Authority: Mr. Stanley, Field Mgr.

Log No. 14.

Wm. F. Majors, No. 4.
Location—8 miles west of Leitchfield.

MISSISSIPPIAN SYSTEM.

Soil, red, soft	18	18
Clay, red, soft	8	26
Limestone, gray, hard	12	36
Shale, gray, soft	4	42
Limestone, hard	18	60
Cave hole (water)	12	72
Limestone, gray, very hard	35	107
Shale, black, soft	6	113
Limestone, black, hard	60	173
Limestone, gray, sandy, hard	26	199
Limestone, black, hard	30	229
Shale, gray, soft	6	235
Limestone, dark, very hard	15	250
Limestone, dark, hard	30	280
Limestone, white, hard	20	300
Shale, black, soft	4	304
Limestone, gray, sandy	20	324
Limestone, dark, sandy	22	346
Limestone, gray, sandy	18	364
Limestone, black, hard, shelly	40	404
Limestone, gray, hard	6	410
Limestone, black, hard	20	430
Shale, dark, soft	6	436
Limestone, black, hard	28	464

Strata	Thickness	Depth
Limestone, black, shelly, hard	20	484
Limestone, brown, soft	25	509
Limestone, gray, hard	7	518
Shale, gray, soft	3	519
Limestone, gray, very hard	6	525
Limestone and sand, gray and hard	5	530
Shale, soft, sandy	5	535
Limestone, white, sandy, hard	8	543
Shale, gray, soft	12	555
Shale, gray, sandy	11	566
Shale and limestone shells	30	596
Shale, black, soft	4	600
Limestone, gray, hard	12	612
Shale, brown	20	632
Limestone shell, hard, some water	3	635
Shale, brown, soft	86	721
Limestone, gray, hard	12	733
Limestone, hard, sandy	20	753
Limestone, gray, hard	5	758
Total depth		758

Authority: Atlantic Oil Producing Co.

Log No. 15.

W. M. Ferry, No. 1, lessor.
Location—10 miles N. W. of Leitchfield.
Begun May, 1919.
Reported production, dry?

MISSISSIPPIAN SYSTEM.

Soil (conductor)	10	10
Sandstone, Big Clifty	18	28
Limestone, white	237	265
Limestone, gray	30	295
Limestone, yellow, sandy	8	303
Limestone, white	32	335
Limestone, sandy, water	5	340
Limestone, gray	40	380
Limestone, brown, sandy	25	405
Limestone, brown, sandy	20	425
Limestone, gray	15	440
Shale, black	8	448
Limestone, gray	7	455
Limestone, brown, sandy	6	461
Limestone, gray, sandy	64	525

Strata	Thickness	Depth
Limestone, gray, sandy	80	605
Limestone, gray, sandy water	45	650
Limestone, gray	20	670
Limestone, gray, sandy	30	700
Limestone, brown	85	785
Limestone, gray, sandy	30	815
Limestone, gray, sandy	43	858
Limestone, sandy (Major?) oil show	10	868
Limestone, some gray sand, mostly lime,	5	873
Oil show	20	893
Limestone, sandy	13	906
Limestone, gray	12	918
Limestone, white, sandy	12	930
Limestone, gray, mixed with shale	27	957
Limestone, black, or asphalt and shale mixed	30	987
Shale black	55	1042
Limestone, black, or asphalt and shale mixed	26	1068

DEVONIAN SYSTEM.

Strata	Thickness	Depth
Shale, black (Chattanooga), 25,000 gas	100	1168
Limestone, gray	6	1174
Limestone, black	8	1182
Limestone, gray	5	1187
Limestone, gray, darker	5	1192
Limestone, dark gray, sandy, 1st Ohio sand	5	1197
Limestone, dark gray, sandy, 1st Ohio sand	5	1202
Limestone, dark gray	5	1207
Limestone, gray	15	1222
Limestone, gray, sandy	5	1227
Limestone, gray, sandy	10	1237
Limestone, gray, sandy, darker	23	1260
Limestone, gray, sandy, darker	10	1270
Shale, black	6	1276
Limestone, dark	6	1282
Limestone, dark	11	1293
Limestone, dark	7	1300
Limestone, gray	24	1324
Shale, black	6	1330
Limestone, gray	18	1348
Limestone, gray, sandy, very strong, smell oil	5	1353

Strata	Thickness	Depth
Limestone, light gray	10	1383
Limestone, gray	5	1368
Limestone, white	10	1378
Total depth		1378

Top of sand.
8½ in. casing 448.
Bottom of sand.
6¼ in. casing 665-1171.

Note: The Devonian and Silurian sediments are not differentiated in this well. The drilling probably stopped in the Silurian.

Log No. 16.

Dink Oller, No. 1, lessor.
Millicken Estate, lessee.
Location—6 miles N. W. Leitchfield.

MISSISSIPPIAN SYSTEM.

Soil	20	20
Limestone, blue, sandy	5	25
Limestone, black	5	30
Limestone, gray	40	70
Shale, blue	12	82
Sand, light brown	4	86
Shale, blue	5	91
Sandstone, Big Clifty	49	140
Shale, blue	8	148
Limestone, blue	8	156
Shale, blue	12	168
Limestone, blue	30	198
Limestone, gray, sandy	17	215
Limestone, light blue, sandy	20	235
Limestone, gray	20	255
Limestone, slate colored	5	260
Limestone, blue	10	270
Limestone, gray	15	285
Limestone, black or flint	5	290
Limestone, gray	15	305
Limestone, yellow	75	380
Limestone, gray	10	390
Limestone, brown	10	400
Limestone, dark brown (water)	95	495
Limestone, light brown	5	500

Strata	Thickness	Depth
Limestone, gray	20	520
Limestone, brown	18	538
Limestone, brown, sandy	15	553
Limestone, gray	11	564
Limestone, brown	6	570
Limestone, blue, sandy	30	600
Limestone, brown	10	610
Limestone, light brown	50	660
Limestone, dark, almost black	30	690
Limestone, dark and shell	5	695
Limestone, dark	15	710
Limestone, gray and shell	25	735
Limestone, dark, fire clay in stone well..	80	815
Limestone, blue	30	845
Limestone, dark	20	865
Limestone, brown and shell	35	900
Limestone, dark	90	990
Limestone, gray, sandy	8	998
Shale, black	18	1016
Limestone, dark blue, and gray shell	6	1022
Limestone or shale, dark	388	1410
Shale, sandy	13	1423

DEVONIAN SYSTEM.

Strata	Thickness	Depth
Shale, black	77	1500
Sand, gray	32	1532
Limestone, gray	153	1685
Limestone, gray, sandy	35	1720
Limestone, brown	5	1725
Limestone, blue	5	1730
Limestone, gray	17	1747
Limestone, white, and sand (salt water)	56	1803
Total depth		1803

8¼ in. casing, 660.

Note: The Devonian and Silurian contact is not distinguishable. This well probably finished in the Silurian.

Log No. 17.

Sam Walker, No. 1, lessor.

Drilled by C. K. Dresser.

Strata	Thickness	Depth
MISSISSIPPIAN SYSTEM.		
Subsoil, yellow sandy clay (conductor)	20	20
Clay, blue, sandy	10	30
Sandstone, Big Clifty, soft and yellow	56	86
Limestone, white, water on top	7	93
Clay, blue	9	102
Limestone, white	80	182
Limestone, white, very hard	3	185
Clay, sandy	5	190
Limestone, white	80	270
Limestone, light brown	35	305
Limestone, light brown, sandy	10	315
Limestone, blue, flinty	7	322
Limestone, cream colored or very light brown	23	345
Limestone, white, sandy	13	358
Limestone, cream colored or very light brown	67	425
Limestone, gray, sandy, sulphur water	36	461
Limestone, light brown, sandy	30	491
Sand, light gray	24	515
Sand, light brown	30	545
Limestone, blue	35	580
Limestone, gray, dark	10	590
Limestone, brown, sandy	12	602
Limestone, gray	38	640
Limestone, dark, shaly	15	655
Limestone, blue	90	745
Limestone, dark, sandy, gas smell	20	765
Limestone, dark blue, sandy	40	805
Limestone, dark, shaly	40	845
Shale, dark, sandy	71	916
Limestone, dark, shaly	129	1045
Limestone, Black Lick	185	1230
Shale, blue	18	1248
Limestone, Blue Lick	50	1298
Limestone, blue, sandy	32	1330
DEVONIAN SYSTEM.		
Shale, Devonian (Black Shale)	83	1413
Sand, gray	8	1421
Limestone, light brown, sandy	5	1426
Limestone, dark brown, sandy	5	1431
Limestone, gray, sandy	30	1461
Limestone blue	71	1532

Strata	Thickness	Depth
Limestone, gray, sandy, gas smell	11	1543
Limestone, blue, shelly	22	1565
Limestone, gray, sandy	13	1578
Limestone light brown, shelly	14	1592
Limestone, gray, sandy	5	1597
Limestone, white, sandy	5	1602
Limestone, gray, sandy, darker	11	1613
Limestone, blue	6	1619
Total depth		1619

Reduced hole from 10 in. to 8 in., 489.

6¼ in. casing, 513.

Well plugged January 28, 1919, from 1300 to 250, and from 600 to 540.

Note: The Devonian and Silurian Systems are not differentiated. The well finished in the Silurian.

Log No. 18.

Enos Cundiff, No. 1, lessor.

Drilled by C. K. Dresser.

MISSISSIPPIAN SYSTEM.

Subsoil (conductor)	15	15
Limestone, white, flinty	60	75
Limestone, white, sandy	15	90
Clay, blue, sandy	20	110
Limestone, white, sandy, water	15	125
Limestone, white	75	200
Limestone, creamy colored like lava	45	245
Limestone, blue, flinty	5	250
Sand, dark brown	5	255
Limestone, cream colored	80	335
Sand, gray, oolitic, water	35	370
Limestone, light brown, sandy	35	405
Sand, light, iron gray	30	435
Sand, light brown	20	455
Limestone, blue	35	490
Sand, gray	10	500
Sand, dark gray, oil show	10	510
Sand, gray	35	545
Limestone, dark, shaly	10	555
Limestone, blue, with showing of flint	15	570
Limestone, blue	62	632

Strata	Thickness	Depth
Limestone, sandy, dark, gas show	23	655
Limestone, dark blue, sandy	60	715
Shale, black	43	758
Sand, dark gray	6	764
Shale, black	6	770
Sand, dark gray	24	794
Shale, black	161	955
Limestone, Blue Lick, shows flint	161	1116
Sand, iron gray, gas show 1128	25	1141
Limestone, Blue Lick, shows flint	44	185
Shale, blue	15	1200
DEVONIAN SYSTEM.		
Shale, black	80	1280
Sand, iron gray, oil show	42	1322
Shale, blue	42	1364
Limestone, blue, shelly	10	1374
Limestone, gray, sandy	18	1392
Limestone, blue, shelly	30	1422
Limestone, brownish gray, sandy	53	1475
Limestone, white, sandy	26	1501
Limestone, or shale, blue	10	1511
Limestone, brown, sandy	15	1526
Limestone, blue, sandy, shaly	24	1550
Shale, dark iron gray, sandy	12	1562
Limestone, blue, shaly	46	1608
Sand. iron gray	10	1618
Shale, dark sandy	16	1634
Shale dark, and gray shells	70½	1704½
Total depth		1704½

8¼ in. casing, 555 feet.

Well plugged at 1200 feet by bridging hole and filling with stone. Then a plug and dirt to 1150, and then bridged at 620 and filled with stone, then a plug and dirt with stone on top to 570.

September 22, 1918.

Contractor: J. W. Reigel.

Note: Devonian-Silurian and Silurian-Ordovician contacts are not defined. The well probably finished a few feet in the Ordovician.

Log No. 19.

O. L. Ferry, No. 1, lessor.

Strata	Thickness	Depth
MISSISSIPPIAN SYSTEM.		
Clay, blue, soft	25	25
Limestone, blue, hard	15	40
Shale, blue, hard	20	60
Limestone, hard	20	80
Limestone, white	15	95
Limestone, gray, soft, oil show	10	105
Shale, blue, hard	5	110
Limestone, white, hard	15	125
Limestone, gray, hard	15	140
Limestone, gray, hard	30	170
Shale, limey, soft	50	220
Shale, blue, soft	8	228
Limestone, gray, soft	12	240
Shale, blue, soft	14	254
Limestone, gray, hard	14	268
Shale, brown, soft-black	15	283
Unrecorded	37	320
Limestone, brown, soft	60	380
Limestone, brown, soft	10	390
Limestone, white, hard	78	468
Limestone, white, soft	17	485
Limestone, white, soft	10	495
Limestone, white, soft	30	525
Total depth		525

6¼ in. casing, 521 feet.

Note: This well did not enter the Devonian sediments.

Log No. 20.

Melvin Young, No. 1, lessor.

Soft, gritty lime impreganted for 65 feet, some gas in top of it (Amber Oil) between 1200-1400

Black shale 1380-1580

Top of Corniferous 1580

Bottom of Corniferous 1665

Top of second Ohio sand 1760

Bottom of second Ohio sand 1785

Casing record:

20'....10"

400'.... 8¼"

500'.... 6⅝"

Authority: R. R. Reynolds.

Note: A partial record only. Mississippian, Devonian and Silurian sediments were successively penetrated by this well.

Log No. 21.

C. S. Brown, No. 1, lessor.
12 mi. S. W. of Leitchfield

Good said with black oil and gas (gas still comes up through water)	250- 280
Gritty lime, show of oil and gas (Major sand?)	740- 780
Black shale	1625-1850
Top of sand	1930

Drilled in 68 feet—4 screws in sand, hole filled up 600 feet sulphur water, show of oil and gas.

Total depth, 1998.

Casing record:

220′	8¼″
720′	6⅝″

Authority: R. R. Reynolds.

Note: A partial record only. Mississippian, Devonian and Silurian sediments were successively penetrated by this well.

GRAYSON COUNTY, KENTUCKY WELLS--DECEMBER 1, 1918

			From Base of Big Clifty Sand to:										
Big Clifty to Sea Level		Above Sea Level	Base Big Clifty sand from surface	1st Sulfur Water	2nd Sulfur Water	Cased last time	Place of Majors Oil	Hunter Gas-place	Top Devonian Shale	Bottom Devonian Shale	Place of 1st Ohio Oil Sand	Second Ohio Oil Sand	Total Depth of Well
670	Stinson	600	70	270	403	480	570	745	980	1118	1186	1280	1250
565	John Dunn	700	135	335	450	623	575	?	1010	1147	1220	1370	1508
423	Hunter, Gas	618	195	255	345	645	625	765	?	?	?	?	964
370	Wallace	592	220	?	360	580	610	?	1076	1236	1320	?	2034
505	Hill	665	160	?	343	600	623	737	1053	1190	1270	1350	1660
240	Meredith	750	510	265	?	400	640	770	1088	1208	1330	1400	1910
252	McGrew	750	498	?	330	420	650	780	1056	1166	1255	1360	2185
566	Tucker	659	84	300	540	666	X		1214	1336	1500		
463	Proctor No. 1	568	105			646			1070	1250			

Tucker "X" New Oil 1113 Plus 84=1197 from top of well.

DATA ON DRILLED WELLS

Herewith is tabulated information concerning the lessors, lessees, location and production of thirty-two oil and gas wells in Grayson County, Kentucky.

The location is given from the courthouse in Leitchfield, Ky.

	Lessors	Lessees	Miles and Direction		Description
1.	Leitchfield	Old L—d Gas Co.	⅛	N. W.	Old gasser. Abandoned.
2.	Charles Stinson	C. H. Dooley	1	N. W.	Small oil. Abandoned.
3.	John T. Dunn	C. H. Dooley	1	N. W. by W.	Small oil. Abandoned.
4.	Xerxes Hunter	Ky. Oil & Ref. Co.	¼	S. W.	2,500,000 ft. gas.
5.	Ed. F Wallace	Ky. Oil & Ref. Co.	¾	S. W.	Dry.
6.	Carl Hazelwood	Ky. Oil & Ref. Co.	6	S E.	2,000,000 ft. gas.
7.	J. E. McGrew	Ky. Oil & Ref. Co.	8	S. E.	Show of oil. Pl. Abandoned.
8	Mary L. Hill	Grayson Co. O. & G. Co.	½	E.	Show of oil. Pl. Abandoned.
9.	W S. Proctor	League O. & G. Co.	1	S. E.	1,000,000 ft. gas. Oil.
10.	R. O.Meredith	Cinoky O. & G. Co.	1	S. E.	Drilling—down 1800 ft
11.	Melvin Young	Asso. Producers	11	W.	Dry.
12.	Alfred Young	Pluto O. & G. Co.	10	W.	Show oil.
13.	Hubert Armes	J. T. Miligan	7	N. W.	Dry. Not completed. Abnd.
14.	Dink Oller	J. T. Miligan	7	N. W.	Not completed.
15.	? ?	? ? Richards	20	W.	Show of oil. Abandoned.
16.	? ? Duncan	Snowden Bros	20	W.	Show of oil. Abandoned.
17.	Millerstown	Ky. Devel. Co.	16	E.	Show of oil. Abandoned.
18.	? ? Muffett	Atlantic O. P. Co.	8	W.	No. 1, 14 bbl. oil.
19.	Wm. Majors	Atlantic O. P. Co.	8	W.	No. 1, 10 bbl. oil.
20.	Wm. Majors	Atlantic O. P. Co.	8	W.	No 2, 10 bbl oil.
21.	Wm. Majors	Atlantic O. P. Co.	8	W.	No. 3, 8 bbl. oil.

	Lessors	Lessees	Miles and Direction		Description
22	Issac Litsey	Atlantic O. P. Co.	8½	W.	No 1. Show oil. Abandoned.
23.	O. L. Ferry	Atlantic O. P. Co.	11	W.	Drilling
24.	Willis G. Stone	Atlantic O. P. Co.	7	N. W.	Drilling
25.	Emma J Tucker	Brady O. & G. Co.	2½	N. W.	Not completed. Abandoned.
26	Charles Brown	Hudson R. O. & G. Co.	12	S. W.	No report. Abandoned.
27.	Ferryhill ?	Carl Dresser	9	W.	No report. Abandoned.
28.	Cook Bros.	Kendall Refining Co.	8	S. W.	Dry.
29.	? Drury	Kendall Refining Co.	10	N. E.	Dry.
30.	John Craig	Alexander Syndicate	5½	E.	Drilling. Now suspended.
31.	Iberia	W. B. Cosby Co.	10½	S. E.	Old abandoned well.
32.	Concord	——————?	12	N. W.	Dry. Abandoned.

REPORTED LOCATIONS.

1.	Ella Lewis	Cinoky Oil & Gas Co.	2½	W.	1 Location
2.	Hardin Porter	——? Tichenor	19	W.	1 Location
3.	Ayer & Lord Tie Co.	——————?	11	S.	3 Location.
4.	Cin. Cooperage Co.	S. W. Coffman	12	S. E.	3 Location.

PETROLIFEROUS SOURCES.

The original source of the petroleum and natural gas found in the rocks underlying Grayson county is not a problem of easy determination at the present time, due to the relatively small amount of drilling that has gone forward and the real paucity of definite information concerning the petroliferous horizons. There appears to be, however, but one possible source for the oil and gases that occur in the Ordovician and Silurian strata. This source rock must be the thin shales and·the thicker and more numerous shaley limestones, probably of close stratigraphic sequence to the "sands." The Devonian limestone lying immediately beneath the Black Shale (Devonian) has been reported dry in its entire thickness in all wells drilled to date. This fact effectually closes the argument of many, at least as

PINE KNOB.

Of striking topographic appearance, with its caves, large and small. this erosional outlier affords much of interest to man, and protection to both beast and bird.

far as this portion of Kentucky is concerned, who advance a so-called theory of downward migration of the oil and gas from the superimposed Black Shale.

The oil and gas occurring in the sandy limestones found at short distances above the Black Shale (Devonian) in some wells

may very rightly be ascribed to the Black Shale. The same. however, probably does not hold true for the oil and gas found in the "Major sand" which occurs generally between 400 and 500 feet above the shale. The ultimate source or mother rock of the petroleum and natural gas of this "sand" is undoubtedly the rather extensive series of limestones and shaley and cherty limestones directly underlying. Operators and geologists who may come to consider the problem of the possible quantities of oil recoverable from the "sands" of the Grayson district, will do well to seriously evaluate the petroleum producing possibilities of an almost entirely limestone and shaley limestone section, such as surrounds these known "sands."

RECAPITULATION.

A brief resume of the geologic conditions attending the development of oil and gas in Grayson county up to the present, lead to the following summary conclusions: (1) Petroleum, natural gas and asphalt occur within the county limits. (2) Natural gas and asphalt rock have been demonstrated to occur in commercial quantities. (3) Petroleum while definitely proven in only upwards of 3 to 5 barrel wells undoubtedly occurs in large and very commercial and valuable quantities. (4) Definite plunging and doming anticlinal structures frequently faulted are recognized at various places in Grayson county. (5) The largest of these is the Rough Creek (anticlinal) Uplift, which is at some places, notably Leitchfield, faulted just to the north of and parallel to its major axis. (6) Structures of secondary importance from a standpoint of size are exemplified by the Meredith and Annetta domes. (7) Premising porous conditions in the established "sands" of this region, petroleum and natural gas occur in strict accordance with the conceptions of anticlinal accumulation. (8) Three petroliferous "sands" are recognized, the first and lowest in the upper Ordovician, the second in the Silurian, and the third in the middle Lower Mississippian. (9) The last sand enumerated is the shallowest, but has been called the "Major sand," and is at this date nearest commercial development. (10) All drilling if unproductive of oil or gas in paying quantities either

immediately above or below the Black Shale (Devonian) should be continued to a depth of 150 to 300 feet below the Black Shale to thoroughly test the Silurian "sand" and the overlying Devonian limestone.

SUMMARY.

Natural gas occurs in very large quantities in Grayson county. It is commercialized only in a small way at Leitchfield. Up to the time of this writing crude oil has been found in but small quantities. It is doubtful if there is today a really commercial oil well in Grayson county, but the prospect for securing commercial wells appears good. Much is still to be learned concerning the petroliferous "sands" of this section. Whether oil pools of sufficient size to pay for operation occur in this region is yet to be determined. Some drilling now under way or proposed may develop such a pool. If production is not encountered, the question will remain unsettled until all the favorable structural localities have been tested.

There have been enough wells drilled in Grayson county to test the entire county had they been wisely located. But unfortunately these wells have been drilled by a number of different companies working independently and frequently at cross purposes with each other. Some of these companies have had only small and scattered areas leased. In such instances drilling was done on the leased areas regardless of favorable or unfavorable structural conditions for oil. It will, therefore, require most test holes to prove the county area than would have been required had the wells been located by one company, or by the different companies co-operating along the best lines and with pooled information.

Manuscript completed Mar. 20, 1921.

X.

A MAUCH CHUNK ISLAND IN THE MISSISSIPPIAN SEAS OF EASTERN KENTUCKY.*

In the Eastern Kentucky coal field on the divide between the Licking river and the Levisa Fork of the Big Sandy river, there exists an elongated structurally elevated area of between

HEART OF THE HILLS.

Lower hills and broader valleys are found west of the Paint Creek uplift. A typical view in the hills of Morgan County about five miles east of West Liberty, the county seat. Lower Pottsville topography.

700 and 1000 square miles. This large structural high has been variously called the "Conglomerate Uplift"** and the Paint

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*Presented before the Geological Section of the American Association for the Advancement of Science, Dec.-Jan., 1919, St. Louis, Mo.

**A. R. Crandall. Geology of Elliott County (2 maps). Ky. Geol. Survey, Series II. 1887. pp. 18, 19.

Creek Uplift,*** and is so located as to overlap parts of Magoffin, Morgan, Elliott, Lawrence, Johnson and Floyd counties. It has a north and south major axis, and has been partially mapped structurally by the Kentucky Geological Survey on the Fire Clay (Pottsville) coal.

The normal dip of the surface Pottsville strata of this region is slightly south of east. The Paint Creek Uplift, culminating in two closed structural highs, the Paint Creek Dome and the Laurel Creek Dome, shows a maximum closed reversal

WHY THE ROAD IS IN THE CREEK BED.
All of the drainage in the vicinity of the Paint Creek uplift has the rejuvinated characteristic. The view is at the juncture of Sandlick and Big Paint Creeks. Sandlick which is the tributary has just cut down through a thick Pottsville layer.

of about 250 feet to the west. A considerable amount of oil and gas prospecting drilling on this structure during the past two years has resulted in defining two large and important oil and gas fields, one on each dome, commercial production being secured principally from the Wier sand which correlates with the

***J. B. Hoeing. Coals of Upper Big Sandy Valley, etc. Ky. Geol. Survey, Series VI, 1913, Vol. I, Part I. pp. 97, 98.

Cuyahoga sandstone in the Waverly group toward the base of the Mississippian System. The best commercial oil production has been secured at hitherto unaccountably high structural positions and along relatively narrow belts.

Summary results of drilling on the flanks of the Paint Creek Uplift show the interval between the Fire Clay coal of the Pottsville and the top of the Big Lime (St. Genevieve-St. Louis) of the Mississippian to rapidly increase from major axial high points. This increase in interval is most pronounced to the east, showing from 150 to 185 feet. It is less to the west, being from 90 to 100 feet. To the north and south the differences are established by a few wells, but are shown to be still more gradual.

A RUGGED WILDERNESS.
The primeval characteristic of Paint Creek has not yet been lost in that section of Morgan County through which it passes as this view near Sand Lick proves. Basal Pottsville topography.

Drilling along the major axis near the points of maximum structural height shows the interval to be from 25 to 35 feet decreased from the normal. A study of the thickness of the Mauch Chunk shows it to be thickening to the east from west normally, but to be very irregular in thickness within a short distance on the crest of the uplift.

A POTTSVILLE WATERFALL.

The small branches all along the main Paint Creek George have made relatively little progress in degrading their channels. Abrasive action alone is effective on the great conglomeratic masses, since it does not contain any material soluble in running water. Many of these falls are from 80 to 100 feet high.

A resultant conception of the subsurface structural conditions at a depth of from 300 to 700 feet establishes the Mississippian strata about the Paint Creek Uplift at very much higher angles of dip than the surface coals. Such conditions indicate plainly primary and secondary folding of the Mississippian rocks, an idea not altogether new, though heretofore vaguely stated.* The Mauch Chunk sediments normally thickening to the east, but found thinly distributed over the top of the Uplift, place the time of the primary folding as the later part of he Mauch Chunk and perhaps a part of the very earliest Pottsville. The irregularity of the thickness of the Mauch Chunk on the crest of the Uplift indicates either strong marine off shore

THE PLATEAU-FORMING POTTSVILLE.
Wider valleys and some little plateau land are found in the section where Sand Lick empties into Big Paint Creek, Johnson County. Characteristic basal Pottsville topography.

currents or possibly a small amount of sub-areal erosion and insular conditions. The thickening of the lowest Pottsville sediments on all sides of the Paint Creek Uplift establishes the end of the first period of folding as principally pre-Pottsville.

*J. B. Hoeing. Coals of Upper Big Sandy Valley, etc. Ky. Geol. Survey, Series IV. 1913. Vol. I, Part I, p. 79.

With the initiation of the uniform and widespread subsidence of the early Pennsylvanian, this Mauch Chunk island after a brief and probably low topographic appearance sank, and Pottsville sediments, sands, muds and coals were laid down first unconformably then later horizontally across it. Subsequently during the time of the Appalachian overthrusts, this old structurally weakened section gave way again under increased and more complicated stresses and strains, resulting in the bringing about of the present faulted and folded structure of the Pottsville as mapped.

The Mississippian strata underlying and already somewhat bowed upward, received at this time their secondary folding. Aside from the purely scientific value attached to the establishment of the older folding of the Mississippian rocks of this part of Kentucky, there is genuine interest in having practically and satisfactorily explained through the secondary folding and consequently increased dip of the Mississippian rocks, the essential cause for the general restriction of the best local oil and gas fields to abnormally high and narrow structural positions.

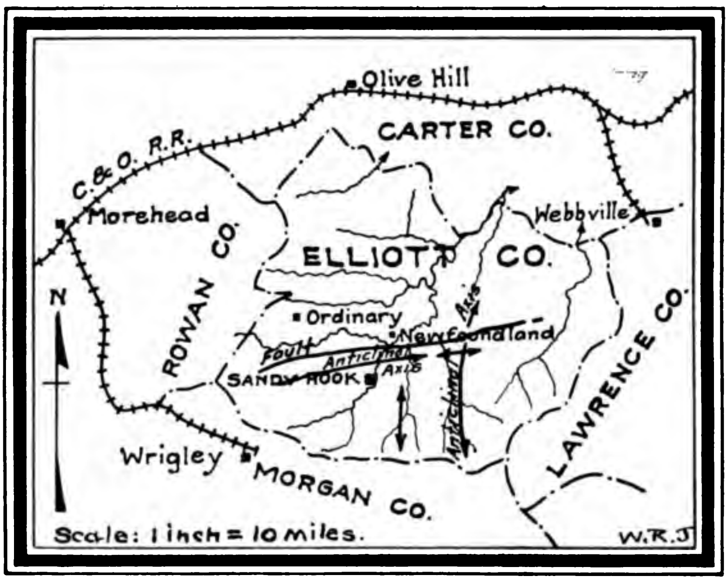
Manuscript completed Dec. 20, 1919.

XI.

THE SANDY HOOK ANTICLINE—A NEWLY DISCOVERED OIL AND GAS STRUCTURE IN ELLIOTT COUNTY, KY.

INTRODUCTION.

That oil and gas structure of a distinctly anticlinal figure existed in south-eastern Elliott county has long been known. This recognized folding* with its generally north and south axis had always been identified in the writer's mind with the well



SKETCH MAP OF ELLIOTT COUNTY, KY.

known Paint Creek Uplift to the south, being regarded in fact as a northward tailing out of that principal fold of Floyd, Johnson, Magoffin, Morgan and Lawrence counties. While these fundamental structural conceptions had become rather

*Crandall, A. R.; Report on the Geology of Elliott County. Ky. Geol. Survey, Series II. John R. Proctor, Dir. 1887.

firmly established, in the course of numerous field examinations of this section of Eastern Kentucky, the possibility of a more or less general duplication in southern Elliott county of the primary structural and oil and gas producing conditions as known and mapped in the Johnson-Morgan-Magoffin field, where the Irvine-Paint Creek fault (northeast-southwest) is paralleled by distinctly anticlinal and doming folds, was not suspected.

Yet in the course of a general field reconnoissance of southern Elliott county early in December, 1920, sufficient structural observations and discoveries were made to lead to this belief. This fuller conception of the deformational conditions existing in southern Elliott county was completely substantiated by a detailed field examination made by the writer

THE LITTLE SANDY FAULT.

The view is to the west at the mouth of the Middle Fork gorge. The steeply southward dipping plane of displacement is readily seen. Topography altered by fault.

alone covering the period from December 15, 1920, to January 1, 1921, all of which time, including Christmas Day, was spent in the field under somewhat adverse climatic conditions. The work was done on horseback and on foot, it being impossible during this period of the year to use either buggy or cheap automobile, though during the dry seasons and by making use of the ridge roads, these conveyances are used in the southern and western part of Elliott county with much success. As a result of these investigations, the Sandy Hook Anticline with

CREST OF THE SANDY HOOK ANTICLINE.
The view is eastward from the entrance to Sheriff Green's farm on Ruin Creek. The massive Pottsville Conglomerate is well shown on the right. On the left the upper portion has been eroded.

a generally northeast and southwest major axis, and the nearly parallel Little Sandy fault, both of which had been noted in their larger aspects by the writer earlier in the month, were farther outlined as presented in this paper and its accompanying maps.

Location of County and Structure.

Elliott county is located just within the northwestern border of the Eastern Coal Field in the northeastern part of Kentucky. It is bounded on the north by Carter county, on the east by Lawrence county, on the south by Morgan county, and on the west by Rowan county. In the order of county formation, Elliott is the one hundred and fourteenth, having been

THE REVERSAL ON MIDDLE FORK.
The view is eastward toward the Hunter farm. The waters of Middle Fork are rather indistinctly outlined in the immediate foreground.

established in 1869 from parts of Carter, Lawrence and Morgan counties. It was named in honor of Judge John M. Elliott, who later, at the time of his assassination on the steps of the old Capitol Hotel in Frankfort in April, 1879, was a Justice of the Court of Appeals. Sandy Hook, formerly known as Martinsburg, a town of about 300 inhabitants, is the county seat.

The Sandy Hook anticline is located in the southwestern quadrant of Elliott county, south of the waters of Laurel Creek and west of the waters of Newcombe Creek. Its major axial

THE LITTLE SANDY FAULT SCARP.
The view is from the Little Sandy-Middle Fork divide just north of Sandy Hook to the north. The cliffs in the mid-distance are the upthrow or north side of the Little Sandy fault. Basal Pottsville topography.

crest extends generally at an angle of N 45 E from near the Ridge post office on South Ruin Creek through the juncture of North and South Ruin Creeks across the Little Sandy River and Middle Fork into the divide between Middle Fork and Newcombe Creeks about midway between the roads from Newfoundland and Sandy Hook to Newcombe Creek.

The Little Sandy fault extends in a generally parallel northeast-southwest undulating line crossing North Ruin Creek above Big Stone post office, the Litte Sandy river about a mile south of its juncture with Laurel Creek, Middle Fork about a mile south of its juncture with the Little Sandy river, Newcombe Creek just north of the mouth of Rocky Branch, and extends on to the northeast, intersecting in prolongation the triangle between Ison Creek and the Little Fork in the vicinity of the Dikes. On the east side of Newcombe Creek the Little Sandy fault crosses almost at right angles the Newcombe Creek anticline, which has a generally north and south major axis.

Drainage and Topography.

The principal drainage of Elliott county is the headwaters of the Little Sandy river and its tributaries, which are as follows: Little Fork (east), Newcombe and Middle Fork (south-central), and Laurel, Big and Little Caney (west), and

WHERE A FAULT TURNED A RIVER.
In the foreground the Little Sandy River is flowing from right to left in an almost south-north direction. At the extreme left it is seen turned by the Little Sandy Fault upthrow block to a west-east direction for some little distance before it passes the break into the canyon country beyond. This panorama shows the low part of the north flank of the Sandy Hook Anticline on the Little Sandy River.

Gimblet and Big Sinking (north). There is a relatively small portion of the extreme headwaters of Big Caney and Laurel Creeks that lies west of the Rowan-Elliott county line in Rowan county, and further to the south a somewhat compensatory portion of the extreme headwaters of Devil's Fork, known as Fulton's Fork, a tributary of the North Fork of Licking river, lies east of the Morgan-Elliott county line in Elliott county. The waters of the Big Sandy, formerly known as the Chatterawha, bound Elliott county on the east, the Licking on the south and west, and Tygarts Creek on the northwest. An arbitrary northwest-southeast line across the waters of the Litte Sandy

THE MIDDLE FORK CANYON.
At all points north of the Little Sandy fault the major streams have incised themselves into box-canyons in the resistant Pottsville Conglomerate.

river is the principal northern boundary of the county. The area of Elliott county accoding to the latest computation is 127,362 acres,* or nearly 200 square miles.

Physiographically Elliott county lies on the northwestern edge of the Cumberland Plateau. With its dendritic streams and insoluble sediments it is an area of considerable rugged-

*Second Ann. Rept. Ky. State Tax Comm., 1919.

ness. Along broad lines it may be divided into two parts on a basis of its characteristic relief. The section east of the Little Sandy river and south of Sandy Hook is a unit with narrow valleys and steep, rather high knife-like ridges which are more or less timbered in second growth and culls. The relief in this section is about 300 feet, and the roads are mostly in the creek bottoms.

The remaining or northwestern portion of Elliott county is largely a deforested region of broad rolling to hilly upland plateau superimposed upon the thick and massive Pottsville Conglomerate. This latter erosion-resisting formation is dissected by several eastward flowing streams, Laurel, Gimblet, the Caneys and Big Sinking being the principal ones. These creeks have their immediate courses in veritable box canyons 150 to 200 feet deep. The maximum relief of this section is about 500 feet, and the roads are principally on the ridges. The maximum relief of the county is a reported ridge elevation of 1500 feet located on the Elliott-Morgan divide. The minimum elevation is found at low water on the Little Sandy river where it crosses the Carter county line. This elevation is undetermined, due to a lack of a near enough bench mark for barometric leveling. It is probably, however, about 550 feet above sea level.

Drainage Modification.

It is of some interest to students of physiography to note in passing that there exists on the crest of the Sandy Hook anticline an excellent example of stream piracy. This drainage modification is almost diagramatic in its simplicity. It concerns the headwaters of the Open Fork of the Little Sandy river, and the Middle Fork of the same major stream. The abandoned channel or "low pass" is located about a mile north of Sandy Hook, and is now occupied by the low gap road that leaves the Sandy Hook-Newfoundland road just north of the John Van Sant farm, and leads to Middle Fork. This road to Middle Fork follows a low swampy branch which in turn occupies a rather large valley or pass in which it is out of adjustment. This low gap is of course the former channel of the

A DESERTED CABIN.

There are many of these in Elliott County. What with the passing of the once wonderful broad leaf forests, the absence of commercial coal over large areas, and the lack of a railroad to furnish a market for home produce, there is not much to hold the poor native son to the soil.

Open Fork, and was principally cut by that stream when it was tributary to Middle Fork.

The immediate cause of the modification is found in the intersection of two sharp meanders of Open Fork and the united Ruin Creeks at a point just north of Sandy Hook. The interlocking of these two meanders occurred, fortunately for the structural geologist, on the crest of the Sandy Hook anticline. But why the channel of the Ruin Creek should have been lower at that time than that of the Open Fork, with its apparently larger drainage basin, is not easy to explain. Until sufficient time is available to work out the detail of this unique piracy, it may be well to leave it with the suggestion that in this case, as in many another in Eastern Kentucky, a fateful complex of structural and lithologic factors have combined to set aside during the still lapse of late Cenozoic time the original physiographic preference of the stream.

STRATIGRAPHY.

The rocks above drainage involved in the Sandy Hook anticline may be referred to the two great Carboniferous groups, the Mississippian System and the overlying Pennsylvanian System. The Mississippian is barely included, its sole repre-

sentative being about a one to twenty foot strip about five hundred feet long of the Chester limestone (Big Lime of drillers) which shows on the Little Sandy river just above the ford, on the upthrow side of the Little Sandy fault. It was brought to the surface here by the lowering of the drainage platform of the Little Sandy river operating in conjunction with the deformational forces which raised the strata forming the anticline prior to its faulting. The dip in the Chester limestone at this place is 3 degrees S. 75 E. It is possible that where the bed of the Little Sandy Creek crosses the major axial line of the anticline that the Chester limestone might be exposed* in a very limited outcrop, but at the time that this examination was made the waters of the Little Sandy were insecurely frozen

WINTER IN THE LITTLE SANDY GORGE.

Snow, ice and high water are certain obstructions in the deep and narrow gorges of Elliott County. Much of the data presented in this report was secured under climatic and physical conditions similar to those here suggested.

and too high to allow an inspection of this detail in the bed of the river's gorge.

*This locality was examined by the writer in April, 1921, and about 100 square feet of limestone was found in the bed and covered by the waters of the Little Sandy River.

North of the area occupied by the Sandy Hook anticline in the bed and the lower walls of Laurel Creek the Chester limestone is exposed in thicknesses ranging from a trace to 35 feet all the way from the headwaters to within a few rods of its juncture with the Little Sandy river. It is also to be seen in much prominence as one progresses northward and northwestward toward the Rowan and Carter county lines in the gorges of Big and Little Caney, Gimblet and Big Sinking Creeks.

Just above the Chester limestone there occurs in outcrops on the head of Laurel Creek and in well logs on the head of Middle Fork a thin shale (20-25 feet) which is quite generally regarded as the uppermost Chester. Where it is pinkish or greenish there is little doubt but that the Chester is the proper classification, but where it is found to be of a drab to slate black color it is without a doubt a replacement sediment and belongs to the overlying Pottsville, the basal division of the Pennsylvanian System. In Elliott county both classifications of this shale occur, but they have never been seen together, either one or the other being absent. Furthermore, it is suspected that

SEAWARD BOUND.

Most of the Pottsville Conglomerate starts on its journey back to the sea as sand grains or white smooth quartz pebbles. Occasionally as in this instance on lower Craney Creek reminant ridge blocks, the size of a house loosened by the frost crash down hundreds of feet into the narrow creek valley below.

this shale may not show on the northern part of the Sandy Hook anticline, as it is not seen in outcrop at the fault or just to the north in the lower part of Laurel Creek.

Overlying this disputable shale there is found a rather thick series of alternating massive sandstones, shales, and thin coals. The sandstones commonly in their lower occurrences and occasionally in thin lenticular phases higher up, exhibit a very marked conglomeratic characteristic, being made up largely of smooth white rounded to elongate quartz pebbles, varying from the size of a pearl to that of a dove's egg. It is from this lithological facies that this division takes its name, the Pottsville Conglomerate. As measured from the top of the Chester limestone on the fault scarp on the Little Sandy river this formation alone measures 185 feet, the shale being regarded as out of the section. There appears to be very little if any thickness of transitional bed between the Chester limestone and the conglomeratic sandstone at this point. The conglomerate sandstone thins to the northwest, and thickens very rapidly to the southeast, where it is found divided in well logs into several distinct massive sandstone members.

SNOWFALL ACCENTUATING STRUCTURE.

Detailed field investigations are generally rendered difficult and unpleasant by snow and ice. But great reversals of structure like this north flank of the Sandy Hook Anticline in the gorge of the Little Sandy River are quite as frequently made more conspicuous by the subtle hand of Winter.

Above the conglomeratic or basal phase of the Pottsville there occurs on the Sandy Hook Anticline on the axial crest in the drainage divide between the Little Sandy river and Middle Fork 340 feet of alternating sandstone, shales, and thin coals. Taken together with the conglomerate, this gives a total thickness for the Pottsville on this structure all of which may be seen above drainage of about 525 feet.

Beginning with the thin shale above the Chester limestone which has been discussed above, and extending downward, the following generalized Mississippian sequence is found as interpreted from the logs of the nearest and most accurately recorded wells which are located to the southeast of the Sandy Hook Anticline. Big Lime 150 to 160 feet, Big Injun sands and shales 360 to 370 feet, Wier sand 35 to 40 feet, Sunbury shale 18 to 24 feet, Berea 85 to 100 feet. Blue shale 18-20 feet.

NORTH FLANK OF THE SANDY HOOK ANTICLINE.
The view is to the east in the canyon of the Little Sandy River about two and one-half miles north of Sandy Hook. The angle of reversal is not as great here as it is close to the fault.

Beneath this occurs the following sequence of Devonian rocks. Black Chattanooga shale (sometimes in part brown) 300 to 350 feet, white shale 30 to 60 feet, Onondaga Limestone 25 to 50 feet. Underlying the Onondaga limestone which is the basal member of the Devonian in Kentucky, occur the Silurian and Ordovician sequences of alternating thin and thick limestones, and shaley limestones, the general thicknesses of which are here omitted since they are not regarded as offering any promise of commercial oil production on this structure.

GENERALIZED GEOLOGICAL SECTION FOR DRILLING ON THE SANDY HOOK ANTICLINE.

Age	Strata in Sequence	Thickness in Feet	Notes
Pennsylvania System.			
Pottsville	Alternating sandstone shale and coals	340	All above drainage.
	Conglomeratic phase including thin shales and sands	175–185	Above and below drainage, depending upon structure.
Mississippian System.			
Chester-St. Louis	Big Lime	150–160	Generally below drainage.
Waverly	Big Injun sandstone and shale	360–370	All below drainage.
	Wier sand (oil sand)	35–40	
	Sunbury shale	18–24	
	Berea Sand (oil sand)	85–100	
	Blue shale	18–20	
Devonian System.			
Upper and Middle Devonian	Chattanooga black shale	300–400	All below drainage.
	Onondaga Limestone	25–50	
Silurian and Ordovician Systems.			

Wells drilled on the Sandy Hook Anticline where the drill starts in the top of the Pottsville Conglomerate should pierce the top of the Wier sand at a depth of 750 feet. Wells that are started in the creek bottoms below the top of the Conglomerate will be correspondingly shallower, and it should be pos-

THE LITTLE SANDY FAULT.
The rives is to the west at the mouth of the Middle Fork canyon near the Hunter farm. The slipping plane is well shown dipping steeply to the left or south, Parallel to it and in the face of the Congomerate may be seen the lines of incipient fracture.

sible to find a few locations along the crest of this anticline where the drilling depths to the Wier sand would not exceed 550 feet. All flank and hillside wells will however be considerably deeper, depending upon distance removed from the crest of the structure and the added height of the topographic elevation.

The average well located at random, however, should not find the drilling depth to the top of the Wier sand greater than 900 feet unless it is located exceptionally high topographically and low structurally. Herewith are appended revised well logs of oil and gas wells drilled slightly to the east and southeast of the Sandy Hook Anticline. It is regrettable that there is such a divergence in the methods and accuracy with which well records are kept in newly developing areas such as Elliott

county. Much has been left out of these logs that would have well served the purpose of further drilling in Elliott county. Acknowledging their inaccuracies, these records are presented, since they represent the best information of its kind concerning the subsurface stratigraphy as it is found by the drilling bit and recognized by the driller himself.

REVISED RECORDS OF WELLS DRILLED FOR OIL AND GAS IN ELLIOTT COUNTY, KY.

Log No. 11.

J. C. Hunter, No. 1, lessor.
Ohio Oil Co., lessee.
Location: ½ mile N. W. of Sandy Hook.
Started March 12, 1921.
Finished.
Production: Oil—not measured.
Cased at 276—top of lime.

Strata			Thickness	Depth
PENNSYLVANIAN SYSTEM.				
Soil			15	15
Clay (Gumbo)			17	32
Sand (Pottsville Conglomerate)			213	245
Shale, black			15	260
MISSISSIPPIAN SYSTEM.				
Limestone, some sand (Big Lime)			76	336
Shale, blue			264	600
Shale, sandy, dark blue gray			140	740
Sand, light, gas smell		Wier Sand 66′	4	744
Sand, light, hard			8	752
Sand and shale, blue gray			4	756
Sand, darker			14	770
Sand, dark			18	788
Sand, gray, white, and oil	Oil 18′		12	800
Sand, gray and dark shale, oil			3	803
Shale, gray and sand, oil, iron pyrites in sand			3	806
Shale, black (Sunbury)			16	822
Sandstone, gray (Berea)			11	833

(Drilling stopped to fish for bailer, Apr. 14, 1921.)

Note: This is the log of the first or discovery well drilled on the Sandy Hook Anticline. The location was made by the writer. Though incomplete at this date it has been inserted since it is the most accurate log of any well yet drilled in Elliott county. It proves the petroliferous nature of the Wier Sand, at least, as the Sandy Hook Anticline.

Log No. 1.

Britt Gibson, lessor, No. 1.
Bourbon Oil Co., et al., lessee.
Located on Middle Fork of Little Sandy River, near Roscoe P. O.
Bar. Alt., 690. ft.
Production, five bbls. oil.
Baume gravity, 33.7 degrees.

PENNSYLVANIAN SYSTEM.

Strata	Thickness	Depth
Soil	22	22
Blue shale	14	36
Black shale	12	48
Blue sand (oil)	12	60
Slate (coal)	23	83
Shale	97	180
Sand	5	185
Shale	75	260
Sand (white)	47	307
Shale	48	355

MISSISSIPPIAN SYSTEM

Limestone (Big Lime)	153	508
Sand (Big Injun)	14	522
Shale and shells	16	538
Shale colored lime, gritty	47	585
Shale gray to white	250	835
Sand, shaly	37	872
Sand, fine (oil) Wier Sand	6	878
Sand, gray (oil) Wier Sand	32	910
Shale, black (Sunbury)	21	931
Sand (Berea) (oil)	99	1030
Blue shale	23	1053

DEVONIAN SYSTEM.

Shale, black (Chattanooga)	342	1395
Shale, white	62	1457
Lime (Corniferous)	6	1463
Limestone, soft	49	1512
Lime	8	1520
Total depth		1520

THE BRITT GIBSON WELL.
This well located on the head of Middle Fork was drilled in to oil in the Wier and Berea Sands. It would probably have been of commercial importance had it been correctly shot. Oil now stands within 25 feet of the casing head.

Log No. 2.

H. H. Evans, leasor, No. 1.
Ohio Fuel, Oil & Gas Company, lessee.
Sarah District.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM.		
Sub-soil	6	6
Shale	4	10
Coal	2	12
Shale	38	50

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Shale, black		15	260
MISSISSIPPIAN SYSTEM.			
Limestone, some sand (Big Lime)		76	336
Shale, blue		264	600
Shale, sandy, dark blue gray		140	740
Sand, light, gas smell	Wier Sand 66'	4	744
Sand, light, hard		8	752
Sand and shale, blue gray		4	756
Sand, darker		14	770
Sand, dark		18	788
Sand, gray, white, and oil	Oil 18'	12	800
Sand, gray and dark shale, oil		3	803
Shale, gray and sand, oil, iron pyrites in sand		3	806
Shale, black (Sunbury)		16	822
Sandstone, gray (Berea)		11	833

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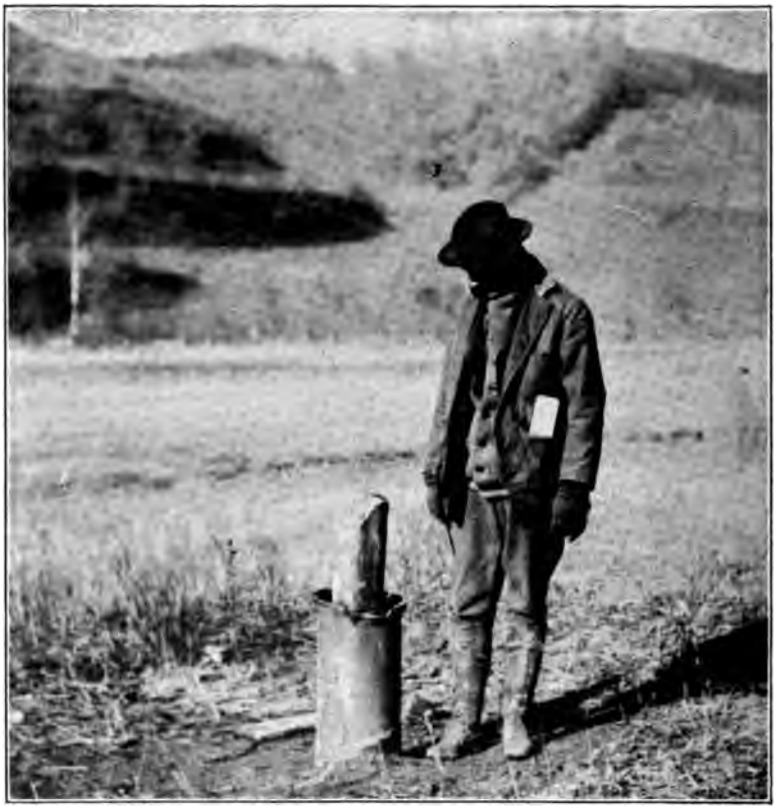
Soil	22	22
Blue shale	14	36
Black shale	12	48
Blue sand (oil)	12	60
Slate (coal)	23	83
Shale	97	180
Sand	5	185
Shale	75	260
Sand (white)	47	307
Shale	48	355

MISSISSIPPIAN SYSTEM

Limestone (Big Lime)	153	508
Sand (Big Injun)	14	522
Shale and shells	16	538
Shale colored lime, gritty	47	585
Shale gray to white	250	835
Sand, shaly	37	872
Sand, fine (oil) Wier Sand	6	878
Sand, gray (oil) Wier Sand	32	910
Shale, black (Sunbury)	21	931
Sand (Berea) (oil)	99	1030
Blue shale	23	1053

DEVONIAN SYSTEM.

Shale, black (Chattanooga)	342	1395
Shale, white	62	1457
Lime (Corniferous)	6	1463
Limestone, soft	49	1512
Lime	8	1520
Total depth		1520



THE BRITT GIBSON WELL.
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Log No. 2.

H. H. Evans, leasor, No. 1.
Ohio Fuel, Oil & Gas Company, lessee.
Sarah District.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM.		
Sub-soil	6	6
Shale	4	10
Coal	2	12
Shale	38	50

Strata	Thickness	Depth
Sand full water	10	60
Shale	40	100
Broken sand and shale	50	150
Broken salt sand	150	300
Broken white salt sand	150	450
Shale	18	468
Maxon sand	10	478
MISSISSIPPIAN SYSTEM		
Little lime	20	498
Shale (Pencil cave)	5	503
Limestone (Big Lime)	163	666
Shells and shale	194	860
Sand (Big Injun)	9	869
Shells and shale	49	918
Sand	5	923
Shells and shale (includes Wier)	107	1030
Coffee shale (Sunbury)	15	1045
Sand (Berea)	50	1095
Shale	5	1100
Sand (Berea, soft)	65	1165
Sand (Berea, hard)	15	1180
Blue shale	20	1200
DEVONIAN SYSTEM.		
Brown shale, cinnamon brown	100	1300
Blue shale	15	1315
Black shale and cinnamon brown	305	1620
White shale	87	1707
Limestone (Corniferous)	71	1778
Total depth		1778

Show oil bottom big lime.
Big Injun, 250,000 ft. Gas (dry).
Hole full of water 923.
Berea hard and coarse.
White sand 1765-1778.
Thru Corniferous dry.

Log No. 3.

Ferret Dials, No. 1, lessor.
Rice Oil Company, 27 William Street, N. Y. City, lessee.
Location—On Newcombe Creek near Isonville.
Casing head elevation, 675 feet.
Completed on December 27, 1917.
Production, 1,000,000 cu. ft. gas estimated.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM.		
Soil	25	25
Shale, hard (water at 50 ft.)	115	140
Sand	30	170
Shale, hard	10	180
Sand	20	200
Shale, hard	40	240
MISSISSIPPIAN SYSTEM		
Lime, white (Big Lime) gas, 50,000	150	390
Sand, good	15	405
Shells and shale, hard (water at 450 ft.)	225	630
Lime, white	40	670
Sand, dark (gas, 50,000 at 715 ft.) (Wier)	80	750
Shale, hard (Sunbury)	20	770
Sand, hard, dark (Berea)	95	865
Shells and shale, hard	29	894
DEVONIAN SYSTEM.		
Black shale	276	1170
Shale, light colored	77	1247
Lime, gritty ("Irvine sand")	35	1282
SILURIAN SYSTEM.		
Lime, white, very hard (gas, 500,000 at 1348 ft.)	118	1400
Total depth		1400

Gas 338-380, 50,000 cu. ft.

Casing record:
30 ft. 10 in.
180 ft. 8¼ in.
560 ft. 6¼ in.

Authority: L. Beckner.

Log No. 4.

Prichard No. 1.
Bourbon Oil & Dev. Co.
Well located on head of Newcombe Creek.
Casing head elevation, 880.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM.		
Shale and sand	95	95
Coal	5	100
Shale	10	110
Sandstone	65	175
Shale	45	220
Sand	20	240
Shale	5	245
Sand	15	260
Shale	3	263
Sand	7	270
Shale	45	315
Sand (bluish at top) rest fine.		
Sand, blue at top, settling	160	475
Dark sand	15	490
Shale	40	530
MISSISSIPPIAN SYSTEM		
Big Lime (white)	142	672
Shale and shells	198(?)	870
Shells (small gas)	5	875
Shale—shells	15	890
Sandy white shale	66	956
Sand Wier (oil)	24	980
Shale	5	985
Sand Wier (oil)	31	1016
Total depth		1016

Hole cased down 672 ft. with 6¼ in. casing.
15 ft. of 10 in. casing also used.
Pay sand entirely through Wier.

Note: The drillers thought this well finished in the Berea Grit, but it finished at 1016 above the Berea in the Wier. W. R. J.

Log No. 5.

Fulton No. 1.
Ohio Cities Gas Co.
Head of Little Fork of Little Sandy River.
Casing head elevation, 784.
Drilled, spring of 1918.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM.		
Soil	10	10
Quicksand	5	15
Sand (dark and hard)	5	20

Strata	Thickness	Depth
Coal	1	21
Soft dark shale	11	32
Hard dark shale	13	45
Coal	1	46
Shale (dark, soft)	54	100
Sand (dark, hard)	15	115
Shale (dark, soft)	20	135
Sand and shale	3	138
Shale (light, soft)	22	160
Sand (dark, hard)	15	175
Shale (light, soft)	20	195
Coal	2	197
Shale (light, soft)	48	245
Sand, dark, soft	20	265
Shale (light, soft)	10	275
Sand, light, hard	30	305
Sand, light, soft	21	326
Sand, hard	4	330
Sand, light	90	420
Shale, dark and soft	3	423
Sand, light, hard	32	455
Sand, dark, hard	10	465
Sand, dark, hard	9	474
Sand	14	488
MISSISSIPPIAN SYSTEM		
Limestone (Big Lime)	166	654
Sand	28	682
Shale, light	30	712
Sand	33	745
Sand and shells	85	830
Lime	15	845
Shale and sand	21	866
Lime	42	908
Sand salt water	12	920
Sand and shale, water	16	936
Shale and shell (light)	35	971
Shale	7	978
Sand (Wier) (salt water)	62	1040
Total depth		1040

16 ft. of wooden conductor.
Casing 20 ft. of 10 in.
474 ft. of 8¼ in.

Note: This well finished in the Wier sand, although the drillers supposed they finished in Berea Grit salt water.—W. R. J.

Log No. 6.

Fulton, No. 2.
Ohio Cities Gas Co.
Head of the Laurel Branch of Little Fork of Sandy River.
Casing head elevation, 848 feet.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM.		
Loose sand	2	2
Sand, light, soft	7	9
Coal	1	10
Sand, light, hard	20	30
Shale, light soft	8	38
Sand, dark, hard	23	61
Shale, light, soft	9	70
Sand, light, hard	25	95
Coal	1	96
Shale, dark, soft	12	108
Sand, dark, hard	6	114
Shale, dark, soft	26	140
Sand (broken)	30	170
Sand, dark, hard	8	178
Sand (broken)	22	200
Shale and shells	68	268
Sand	32	300
Coal	3	303
Shale, light	27	330
Sand, light	125	455
Shale, dark	11	466
MISSISSIPPIAN SYSTEM		
Big Lime	128	594
Sand, light brown, hard	201	795
Shale, light	35	830
Bastard lime	20	850
Shale, light	57	907
Sand	50	957
Sand, mixed with brown shale	11	968
Sand (Wier), salt water at 972	42	1010
Shale (Sunbury)	20	1030
Sand, hard, Berea?	17	1047
Shale	18	1065
Sand, hard, gray (Berea in part)	160	1225

Strata	Thickness	Depth
DEVONIAN SYSTEM.		
Shale, brown	100	1325
Shale, white	10	1335
Shale, brown, soft	250	1585
Shale, gray, soft	91	1676
Limestone, "Irvine Sand"	3	1679
Limestone "Sand," brown, hard	9	1688
Total depth		1688

Irvine sand dry, Berea Grit, salt water.

Well completed October 9, 1918.

Log No. 7.

Dials, No. 1.

Well drilled on Left Fork of Newcombe Creek, ¼ mile above Isonville.

Casing head elevation, 670 feet.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM.		
Quicksand	25	25
Shale	115	140
Sand	30	170
Shale	10	180
Sand	20	200
Shale	40	240
MISSISSIPPIAN SYSTEM		
Limestone (Big Lime)	150	390
Sand	15	405
Shale	225	630
Lime	40	670
Gray sand (gas) (Wier)	80	750
Shale	20	770
Sand (Berea)	95	865
Shale	29	894
DEVONIAN SYSTEM.		
Brown shale	336	1230
White clay	110	1340
Limestone "Irvine sand"	37	1377
Gritty lime	123	1500
Total depth		1500

First pay gas....1347
Pay gas................1366
Depth of well, 1500 ft.
Casing 30 ft. 10 in. 180 ft. 8¼ in. 560 ft. 6¼ in.
Well drilled in the spring of 1918.

Log No. 8.

Gillum, No. 1.
Badger Oil Co.
Well drilled 1-5 mile above the forks of Rocky Branch, a branch of Newcombe Creek, and near Burke P. O.
Casing head elevation, 768 feet.

Strata		Thickness	Depth
PENNSYLVANIAN SYSTEM.			
Soil		5	5
Sand		215	220
Shale		7	227
Coal		3	230
Shale		14	244
MISSISSIPPIAN SYSTEM			
Limestone (Big Lime)		156	400
Shale		100	500
Shale, white		165	665
Sand, gray (small oil)		30	695
Shale		5	700
Sand		27	727
Shale		3	730
Sand, small gas 734	Wier sand correlative 37 feet	9	739
Shale		7	746
Sand, white, hard		5	751
Sand, gray		5	756
Shale		11	767
Shale, brown (Sunbury)		10	777
Sand (Berea)		53	830
Shale		60	890
Shale and sand		25	915
DEVONIAN SYSTEM.			
Shale, brown		380	1295
Shale, white		47	1342
Limestone "Irvine sand"		50	1392
Total depth			1392

Both Berea and Irvine very hard and dry.
340 ft. 6¼ in. casing.

Log No. 9.

Solomon Lewis, No. 1.
Buck Fork of Middle Fork.
Drilled by Bourbon Oil Co.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM.		
Soil	3	3
Sandy shale	101	104
Sand	3½	107½
Coal	3½	111
Shale	9	120
Sand (slight showing of oil with water)	4	124
Blue shale	176	300
Water sand	16	316
Sand	29	345
White sand	85	430
Blue shale (sticky)	57	487
MISSISSIPPIAN SYSTEM		
Limestone (Big Lime) (Break 50 to 57 ft. in lime, showing of oil in break)	113	600
Sand (Big Injun) green	125	725
Shale	3	728
Sand	29	757
Sand, blue and gray	146	923
Shale, blue	27	950
Sand, dark gray	22	972
Sand (oil show) — Wier sand correlative 52 feet	31	1003
Sand, "pay oil" — Wier sand correlative 52 feet	15	1018
Sand (tight) "Pay" — Wier sand correlative 52 feet	6	1024
Shale, black—Sunbury	20	1044
Sand, very hard (Berea)	20	1064
Sand (soft 1120-1135), Berea oil	71	1135
Total depth		1135

6¼ in casing 725 feet.

Best pay 1044-1058.

Hardens 1058-1064.

Drilled to 1135 ft. No further break.

Soft 1120-1135.

Showed better at bottom.

Log No. 10.

Ves Peters, No. 1, lessor.
Location—Left Fork of Newcombe Creek, ¾ mile above Isonville.
Partial record.

Strata	Thickness	Depth
PENNSYLVANIAN SYSTEM.		
Soil	19	19
Shale	156	175
Sand	125	300
Shale	10	310
Sand	20	330
Shale	38	368
MISSISSIPPIAN SYSTEM		
Limestone (Big Lime)	140	508
Shale	207	715
Limestone?	68	783
Sand Wier?	50	833

Casing 10 ft. 10 in.
Casing 165 ft. 8¼ in.
Casing 543 ft. 6¼ in.

This well is reported to have been drilled through the Devonian limestone.

STRUCTURE.

The Sandy Hook Anticline is in its fundamental conception a simple anticlinal fold showing a slight tendency toward doming along its major axial crest in the vicinity of the juncture of Ruin Creeks, and the Little Sandy river slightly southwestward toward the Ridge post office. The anticline is faulted (Little Sandy fault) low on its northern flank along a line more or less parallel with the major axial crest of the structure. Evidence of this fact is readily seen in the angle of dip of the rock strata adjacent to each other on the up-throw (north) and down-throw (south) sides of the plane of displacement. This angle on Middle Fork is 8 degrees in both cases. On the Little Sandy river it is 9 degrees on both sides in the same respective positions.

Acceptance of this contention premises the following structural sequence: (1) Initiation of great crestal pressures

from the south and southeast probably during the emergence of the Pottsville sediments and later. (2) Lateral compacting of the sediments, development of countless generally east-west minor folds, and the erection of a few great folds of which the Pine Mountain Anticline, the Irvine-Paintsville Anticline, and the Sandy Hook Anticline were the largest. (3) Release of southeast pressures due probably to overthrusting of the Pine Mountain Fault. (4) Consequent normal faulting of the large folds to the north, including the Sandy Hook Anticline.

THE OPEN FORK REVERSAL.
The beds shown are near the top of the Pottsville Conglomerate and they are dipping to the northeast at about 6 degrees. Note the icicles extending into the water.

On the face of the Little Sandy fault on Middle Fork the plane of displacement is inclined to the south at an angle of 60 degrees. The amount of displacement here is about 160 feet. On the Little Sandy, the fault plane dip is slightly steeper, being 55 degrees from the vertical. The throw on the Little Sandy river is between 190 and 200 feet, it being impossible to accurately determine the distance as the top of the conglomerate is unexposed on the down-throw side. The dip of the fault plane on Newcombe Creek is S 10 E, and the angle is 50

degrees from the vertical. The strike of the fault at this point is N 80 E. If this line is followed along its prolongation it will intercept the diked area on Ison and Hamilton Creeks which are northeast flowing tributaries of the Little Fork in the eastern part of the county.

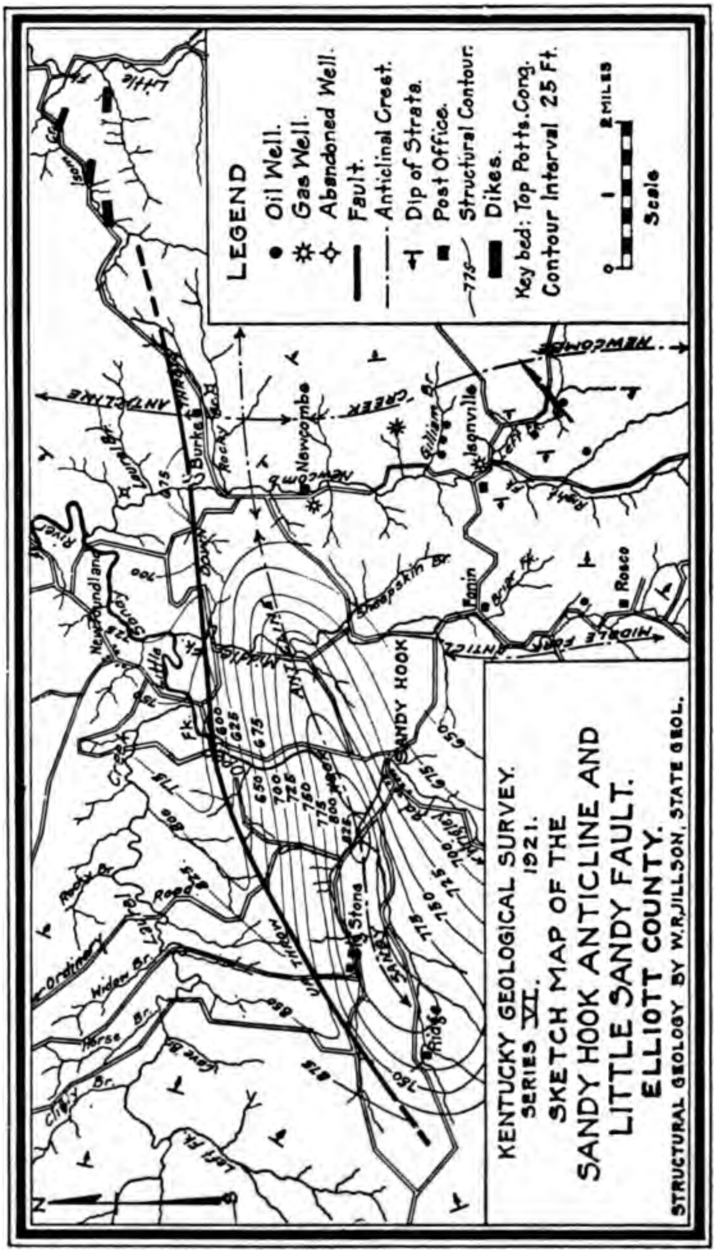
When followed to the westward from the Little Sandy river, the fault which there apparently has nearly an east and west strike bends strongly to the southwest, and may be seen

THE LITTLE SANDY FAULT.

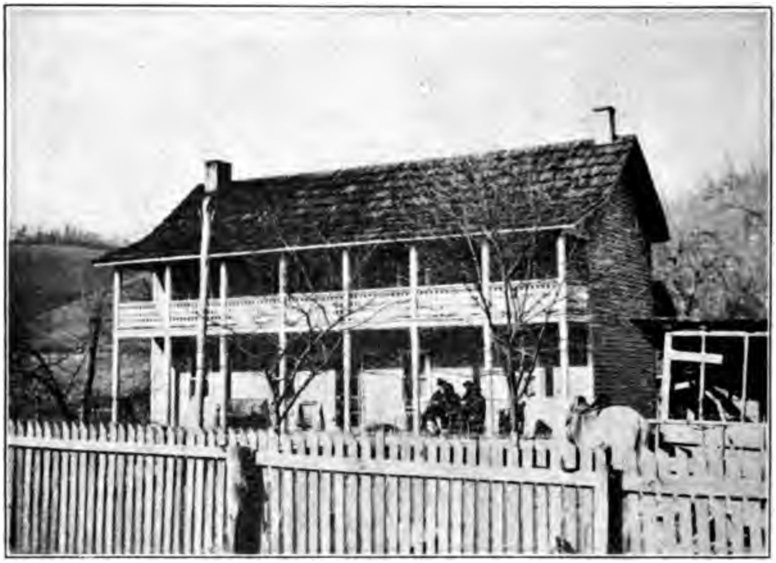
The view is to the east and is taken on the Little Sandy River just above the mouth of Laurel Creek. The angle of the fault plane 55 degrees to 60 degrees to the south can well be seen in this picture. Topography altered by fault.

as small escarpments and displacements at several points until it finally crosses North Ruin Creek about a mile west of Big Stone post office and is lost in the divide between the North and South Ruin Creeks.

The Sandy Hook Anticline is approximately eight miles long when measured on its major axis, and four miles wide when followed across its minor axis. Its highest point of structural elevation is near and just west of the juncture of Little Sandy river and North and South Ruin Creeks where the top of the conglomerate is 825 feet above sea level. The datum of all elevations in this report is 752 feet above sea level


LEGEND
Oil Well.
Gas Well.
Abandoned Well.
Fault.
Anticlinal Crest.
Dip of Strata.
Post Office.
Structural Contour.
Dikes.
Key bed: Top Potts. Cong.
Contour Interval 25 Ft.
0 1 2 MILES
Scale
KENTUCKY GEOLOGICAL SURVEY.
SERIES VI. 1921.
SKETCH MAP OF THE
SANDY HOOK ANTICLINE AND
LITTLE SANDY FAULT.
ELLIOTT COUNTY.
STRUCTURAL GEOLOGY BY W.R.JILLSON, STATE GEOL.

on the northwest corner of the Elliott county court house yard at Sandy Hook. At the fault on Little Sandy river the top of the Pottsville has bowed down to the north within two miles so that it is covered by the surface of the water which is 600 feet above sea level. The difference of these elevations gives a



THE MOUNTAIN MANSION.

This four room double porch homestead on the headwaters of Middle Fork is typical of the best in architecture and living conditions in eastern Kentucky. It can be found as a type slightly modified on every creek of size in this part of the State.

known reversal of at least 225 feet, and this might be slightly increased by very accurate and precise transit levels.

On the northern or reversal flank the dips close to the fault at all points observed are uniformly steep, but these rapidly become less as the structure is ascended until a point is reached approaching the crest. Here the dips again increase slightly until the top is reached. The south flank is much the same as the north, especially near the crest, but farther down the influence of the normal southeast dip begins to show itself and the flank tails off at a much lower angle.

Oil and Gas Possibilities.

The Sandy Hook Anticline is undrilled, and all statements concerning its productive possibilities must be based upon parallel conditions found elsewhere. Such parallel conditions are fortunately easily referred to in the develpment of the Johnson-Magoffin oil and gas field on the Paint Creek Dome which is located on an air line twenty miles to the south of the crest of the Sandy Hook Anticline.

If the Irvine-Paint Creek fault and the Little Sandy fault be compared, it will be found that they are essentially parallel northeast southwest normal faults, with plane of displacement dipping to the south, the only difference being that the Little Sandy fault with a throw of about 200 feet is greater than the one to the south. If the Rockhouse Anticline in Magoffin county and the Paintsville Anticline in Johnson county be taken together and compared with the Sandy Hook Anticline, the structure will again be seen to be very similar, the only differ-

THE SOL LEWIS WELL.
This oil well—a small producer—located on the head of Middle Fork was ruined by the shot and has been practically abandoned.

ence being that the Paint Creeek Dome is crossed by the Irvine-Paint Creek fault high on its northern or reversal flank, while the Sandy Hook Anticline is broken way down on its reversal side near the syncline. This situation gives a possibly pro-

ductive north flank to the Sandy Hook Anticline south of its fault which the Paint Creek Dome has not been shown to possess just south of its fault.

The Paint Creek structure, however, is greatly compensated for this loss by the southward prolongation of its structural-high along the generally north-south Paint Creek Uplift, giving its present largest productive oil field. This structural characteristic is altogether absent from the Sandy Hook Anticline. It is found, however, farther to the east in Elliott county on and east of Newcombe Creek, as a reference to the map herein included shows.

A comparisan of the general stratigraphy and possibly productive sands of the Johnson-Magoffin field and this prospective field in Elliott county on the Sandy Hook Anticline shows a very similar sequence. The largest productive sand in Magoffin county is the Wier of the lower Mississippian System. The Berea is also a producer, though smaller and somewhat deeper. In Elliott county both of these sands are found in similar or greater thicknesses and are productive.

The nearest Wier sand producing oil well to the Sandy Hook Anticline is the Britt Gibson No. 1, located four miles southeast of Sandy Hook post office on the head of Middle Fork, near Roscoe. This well was drilled into production in 1919 by the Bourbon Oil Co., et al., and it is claimed was spoiled through improper methods of shooting and casing. However this may be, and although the well has since been allowed to stand open and school children have nearly filled it with all kinds of rubbish, the writer by some little effort was able on December 12, 1920, to take from it a sample of green oil which was then within fifty feet of the top of the casing. An analysis of this oil is herewith appended, as is an analysis of a sample taken on December 13 from the Gail Peters No. 1, located on the Left Fork of Newcombe Creek.

This Peters well which was then flowing naturally under a very small head of gas with the pump jack up, is reported to have pumped and flowed thirty barrels within part of a day. Since it, however, has never been given a full ten day test, to the writer's knowledge, it is impossible to say exactly what its production will settle to, but it is estimated at from ten to

THE GAIL PETERS NO. 1.
This well is probably the best oiler now drilled in Elliott County. Though rigged with a pump-jack, if let open, it will flow natural with a slight gas head.

fifteen barrels. The No. 2 well on the Peters lease is about the same, or possibly not quite so large. Both of these wells and a number of other oil and gas wells on Newcombe Creek are located on the west side of the Newcombe Creek Anticline. The Britt Gibson well is located on the east side of the small Middle Fork Anticline or Dome. Neither of these named structures are as large as the Sandy Hook Anticline, yet they produce oil and gas from both the Wier and Berea, and in commercial quantities. The lithologic nature of the Wier and Berea oil sands on the Sandy Hook Anticline remains to be learned as a result of the first prospecting. If the Wier sand is fairly thick—upwards of sixty feet—and soft or loose commercial oil in fair sized wells may be reasonably expected. If the sand is hard and tight less favorable results will probably be realized. The same applies to the Berea sand.

PETROLEUM ANALYSES.

Analysis No. 1.

Laboratory No. G-4037.—Petroleum, labeled "Crude oil from the Britt Gibson No. 1, Wier-Berea. Located near Roscoe P. O., on Middle Fork, Little Sandy River, Elliott County, Ky. Collected by W. R. Jillson, December 11, 1920." Received from W. R. Jillson December 17, 1920 Sample, rather thick, dark brown oil.

Specific gravity 0.855, equivalent to 33.7° B.

Distillate below 150° C. (302° F.)........	15.0%	(Gasoline fraction)
Distillate 150 to 300° C. (302-572° F.)..	34.0%	(Burning oil fraction)
Thick, brown tar	51.0%	
Total	100.0%	

Began to distill at 46° C. (115° F.)
Sulphur 0.20 per cent.
Analysis by A. M. Peter, Chief Chemist.
Jan. 21, 1921.

Analysis No. 2.

Laboratory No. G-4038.—Petroleum, labeled "Crude oil from the Gail Peters No. 1, Wier-Berea. Located south of Isonville P. O., on Newcombe Creek, Elliott County, Ky. Collected by W. R. Jillson, 12-12-20." Received from W. R. Jillson, December 17, 1920. Sample, a rather thick, dark brown oil.

Specific gravity 0.8555, equivalent to 33.6° B.

Distillate below 150° C. (302° F.)........	15.4%	(Gasoline fraction)
Distillate 150 to 300° C. (302-572° F.)..	31.2%	(Burning oil fraction)
Thick, brown tar	53.4%	
Total	100.0%	

Began to distill at 45° C. (113° F.)
Sulphur 0.17%.
Analysis by A. M. Peter, Chief Chemist.
Jan. 21, 1921.

SUMMARY CONSIDERATIONS.

(1) The Sandy Hook Anticline as outlined by twenty-five foot contours on the accompanying map is an established fact. (2) It is the largest well known and untested structure in Eastern Kentucky. Drilling depths at from 600 to 850 feet will be from 200 to 500 feet shallower than any other field located on a similar structure in this part of the state. (4)

Commercial oil and gas production is found in the Wier and Berea sands within four and five miles of this structure. (5) The Cumberland Pipeline at the Martha terminal is within twelve miles in an air line from Sandy Hook post office. (6) The Wier and the Berea oil sands as known in Johnson, Magoffin, Lawrence and Elliott counties are true silica sands, thick and long-lived. (7) Fairly good ridge roads are to be

THE GAIL PETERS LEASE.
At the present time this farm on the left fork of Newcombe Creek is the best oil producing lease in Elliott County. Topography of the Lower Pottsville.

found in the vicinity of Sandy Hook, adequate in dry weather for hauling heavy portable rigs and casing. (8) Sandy Hook is reached by mail-hack or horseback from either Morehead or Olive Hill, the distance being about 25 miles. The nearest railroad connection is Wrigley in Morgan county on the North Fork Railroad, which makes connections with the Chesapeake and Ohio Railroad at Morehead. The distance from Wrigley to Sandy Hook is ten miles, and may be made either by mail-hack or horseback.

Annotated Bibliography.

The literature pertaining to the oil and gas geology of Elliott county is fragmentary and scattered. The principal

examinations have been made by the Kentucky Geological Survey. Reports and maps covering sporadic work have been published and are here listed chronologically. So far as the writer has been able to ascertain, there is not to be found anywhere in this body of literature any certain or specific reference to those structural features of Elliott county here presented and described as the Sandy Hook Anticline and the Little Sandy Fault. Excepting a small area of about ten square miles near Stephens Post office on the Little Fork, which is included in the Kenova quadrangle, Elliott county is unmapped topographically. No portion of this small topographically mapped area touches the Sandy Hook anticline.

1861

Lesley, Joseph P., Jr.

Topographical and Geological Report of the Western Margin of the Eastern Coal Field. Ky. Geol. Survey, Series I, Vol. IV, 1861, pp. 457-463.

Descriptive of head waters of Little Sandy, Laurel, Gimblet, etc., then Carter County, now Elliott County.

1876

Moore, P. N.

Report on the Iron Ores of Greenup, Boyd, and Carter Counties. Ky. Geol. Survey, Series II, Vol. I, pp. 1-78.

References to northeastern Elliott County, now Carter County.

1877

Crandall, A. R.

Report on the Geology of Greenup, Carter and Boyd Counties, and a part of Lawrence County. Ky. Geol. Survey, Series II, Vol. II, pp. 1-77. 31 full page sectional plates, 1 diagram.

References to northeastern Elliott County on the Little Sandy River, then Carter County. Gives geologic sections.

1886

Diller, J. S.

Notes on the Peridotite of Elliott County, Kentucky. 6 pp. Reprint from Am. Jour. So., Aug., 1886, published again with the report on the Geology of Elliott County by A. R. Crandall.

Location of peridotite dikes. Petrographic classification of peridotites and description. Two hypotheses of occurrences advanced. 9 analyses of peridotites and other nearby rocks presented. (C. f. Louisville Pub. Lib.)

1886

Diller, J. S.

The Genesis of the Diamond. 3 pp. Reprinted for "Science," Oct. 29, 1886.

Chiefly remarks concerning the theory advanced by Prof. Carrill Lewis that diamonds occur along lines of contact metamorphism as in the case of the Elliott County, Kentucky, dikes. The idea is scouted, but it is suggested that it might be worth while to make careful examination where the geologic conditions warrant it. (C. f. Louisville Pub. Lib.)

1887

Crandall, A. R.

Report on the Geology of Elliott County. Stereotyped for the Survey by John D. Wood, Public Printer and Binder. 16 pp. 3 full page sections, 4 illus. 2 geological maps. A, small, scale 4 miles equals 1 in. Colored of Johnson, Lawrence, Boyd, Elliott, Carter and part of Morgan Counties showing conglomerate uplift (Paint Creek Uplift) and Elliott County dikes. B, large, of Elliott County, scale 2 miles equals 1 inch.

Geographic location, general geology, topography, drainage of the Little Sandy River tributary to the Ohio. Forests, hard and soft wood broadleafs. Discusses occurrence of the peridotite dikes and association with old abandoned furnace. Coals and iron ores located, discussed, and measured generally.

No reference to the Sandy Hook Anticline or the Little Sandy Fault or the oil and gas producing possibilities of Elliott County. (C. f. Louisville Pub. Lib.)

1887

Crandall, A. R.

Notes on the Elliott County Dikes, Eastern Kentucky. 3 pp., published with the report on Geology of Elliott County by same author.

Location of the trap dike in Elliott County on Critche's Creek of the Little Fork of the Little Sandy River. Extent, general geology of occurrence and possible structural relations are advanced. (C. f. Louisville Pub. Lib.)

1908

Phalen, William Clifton.

Economic Geology of the Kenova Quadrangle. (Kentucky, Ohio and West Va.) U. S. G. S. Bull. 349. (Book and folio form with topographic, structural, areal, and economic geologic maps, scale 1-125,000.)

An exceptionally good discussion of the general and economic geology of the area just to the east of Elliott County and including about ten square miles of Elliott County on the waters of Little Fork near Stephens postoffice.

1919

Jillson, W. R.

The Oil and Gas Resources of Kentucky. 650 pp., 100 illustrations. Dept. of Geol. and Forestry of Kentucky, Series V, Vol. I., also second edition, 1920.

Reference as follows: Elliott county. Natural gas in 42; Waverly Sands 83, described oil and gas and structure 131, well logs 261, 262. Separate structural map of Newcombe Creek Anticline included in separate packet accompanying.

1919

Miller, A. M.

The Geology of Kentucky. 392 pp., 114 illustrations. Dept. of Geol. and Forestry of Kentucky, Series V, Bull. II.

Reference as follows: Elliott County, peridotite dikes, 6, 233, 244, 245; diamond structure, 244; coal, 259, 267; minerals, 343, 348, 350, 351. Reference is made to the Newcombe Creek Anticline, pp. 232 and 233.

1920

Jillson, W. R.

Contributions to Kentucky Geology. 280 pp. Sixty-five illustrations. Dept. of Geol. and Forestry of Kentucky, Series V, Vol. IV.

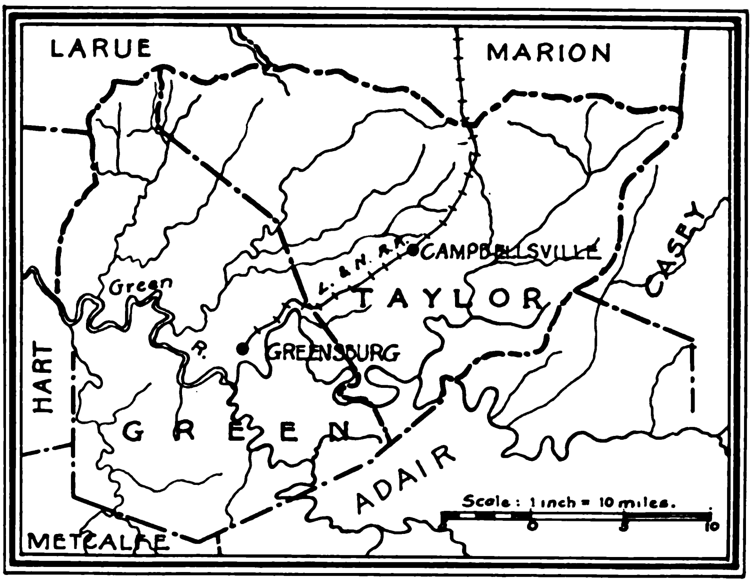
Reference as follows: Elliott County Gas Fields, 31; well logs, 202.

Manuscript completed Feb. 1, 1921.

XII.

THE CAMPBELLSVILLE ANTICLINE IN TAYLOR COUNTY.

The occurrence of relatively large amounts of gas within a somewhat restricted area in western Taylor county, Ky., has for several years suggested the possibility of the occurrence in that vicinity of a definite structural fold of such size as to warrant careful investigation. The paucity of definite geologic information of an oil and gas character with respect to this area made necessary a careful reconnoissance of the section which was carried on by the writer personally, October 31, November 1 and 2, 1920. Stratigraphic observations were made at Merrimac, a point several miles east of Campbellsville,



GREEN AND TAYLOR COUNTIES.
Sketch map showing geography of Green and Taylor and adjoining counties. The Campbellsville Anticline lies just east of the Green-Taylor line.

to determine the nature of the Devonian limestone and the underlying Ordovician limestone. These studies were necessary to throw light on the lithology and contact conditions as ex-

isting between the Chattanooga black (Devonian) shale and the Hamilton or Onondaga (Devonian) limestone. Aid in the more accurate breaking up of the well logs of the Campbellsville area was also secured through this observation of outcrop

In carrying out the field investigation a rectangular area of about eighty square miles was covered. This block extends to the north as far as Maxton, west as far as Highland school house (thereby overlapping the Green county line from one to two miles), and south as far as the Miller farm near Atchley Mill. The eastern limit is Campbellsville. The work was almost entirely of a subsurface nature, elevations being established by use of duplicate and checked aneroid barometers. This survey is tied into a datum of 804.1 feet above sea level as given by the Engineering Department of the Louisville and Nashville Railroad in their profile for elevation of the tracks over bridge No. 13 adjacent to the Campbellsville station. The result of plotting of the sub-surface elevations of the base of the Chattanooga black shale (Devonian) was the outlining of a distinct fold located in central western Taylor county. The major axis of this fold runs slightly east of north and lies about five miles west of Campbellsville.

Location and Stratigraphy.

Taylor county is located in the central part of Kentucky. It is bounded on the north by Larue and Marion counties, on the east by Casey county, on the south by Adair county and on the west by Green county. Its county seat is Campbellsville, a town of 3,000 people, served by the Louisville and Nashville Railroad. The principal drainage of Taylor county is that of the Green river which crosses the southern nipple of the county. Robinson Creek in the east and the three forks of Pitman Creek in the west are the chief lines of tributary drainage. Taylor county has very few good roads, the best being miserably kept toll roads, and the worst tortuous dirt county or farm roads which in wet weather are almost impassable.

The rocks exposed at the surface on the Campbellsville anticline are the limestones and cherty limestones and calcar-

eous shales of the Warsaw and Fort Payne formations, basal divisions of the Mississippian System. At a very few places, principally in the vicinity of the Hall and Campbell wells, the remnants of the St. Louis limestone are found capping the Lower Mississippian rocks. At these points drilling would naturally be a little deeper than at other points, structure be-

THE J. H. HILL GASSER.
This well is located about a mile southwest of Saloma post office. It is one of the large gas reserves of Taylor County for it has never been connected to the line.

ing discounted. The thickness of the exposed and unexposed Mississippian strata varies from 290 to 365 feet.

Underlying the Mississippian series is the Chattanooga black shale (Devonian) and the Hamilton or Onondaga limestone, both belonging to the Devonian System. The latter is the "cap rock" of drillers, and ranges between 3 and 4 feet in thickness. Directly underlying this occurs the uppermost Ordovician strata composed of greenish to pink shales and limey shales, and intercalated limestones which vary from thin to massive. The Ordovician sediments in the Campbellsville-West area are at least 2500 feet thick and probably over 3000,

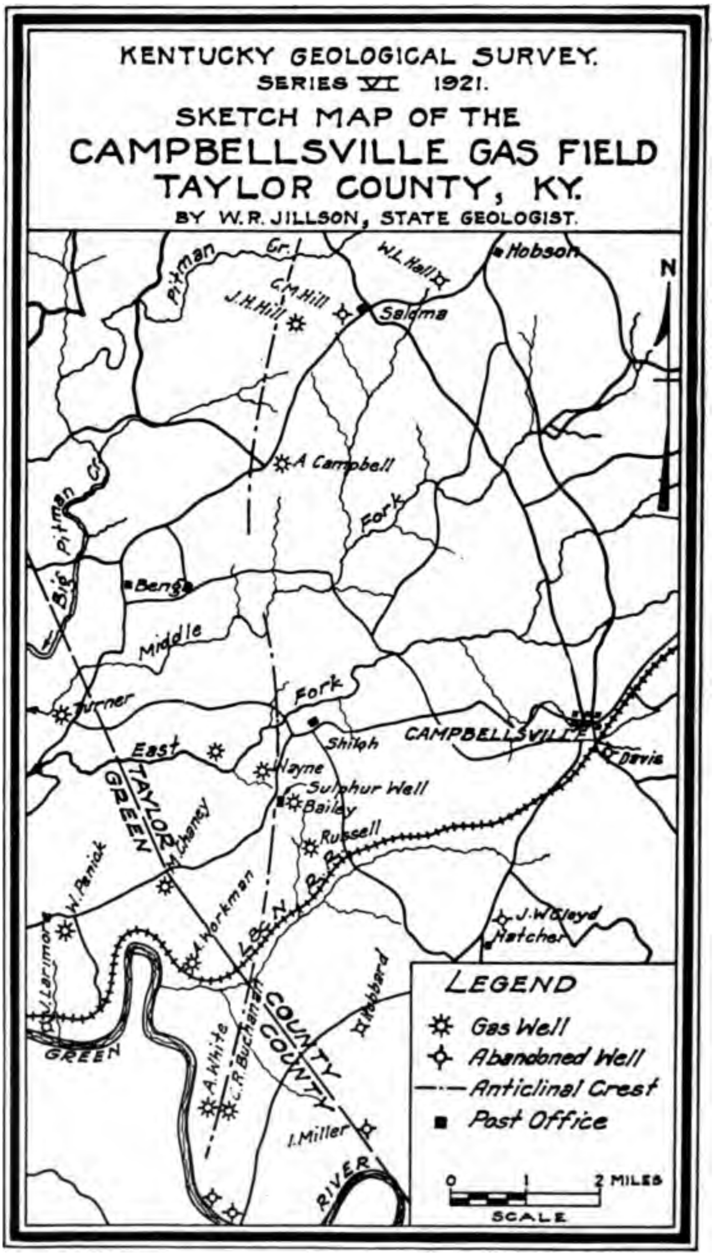
their actual thickness being impossible to determine because of the lack of deep wells in this immediate vicinity. A deep dry test was drilled on the Leonard farm between Mansville and Merrimac to a depth of 2800 feet it is reported in 1917. Located in the north-eastern part of the county where the Mississippian cover is thin, this deep well should have finished close to the bottom of the Ordovician, if indeed it did not enter the Cambrian. The record of this interesting well has not been available for study and plotting of the sedimentary sequence.

It will be noted that in this stratigraphic enumeration the Silurian has been omitted. A line joining its eastern-most points of thinning and disappearance in Marion county to the north, and Allen county to the southwest, would pass considerably to the west of the area examined. Furthermore, the Silurian as such cannot be definitely recognized in the well logs as they are given by the driller. But it is still possible that it does extend as far east as a portion of this area, though it is not probable, nor material if it does.

Structural Geology.

The normal dip of the rock strata in the vicinity of Campbellsville is about south 80 degrees west, or nearly due west. Any considerable changes from this normal dip would probably if projected far enough produce either a terrace, or an anticlinal fold. Certain changes of dip, with pronounced reversals, might produce that special kind of anticline known as a dome. Criteria establishing changes in the subsurface dip at various points, therefore, became a principal object of the investigation.

In working this area, all the available records of wells in the vicinity of the large gas area were secured. Following this, barometric elevations were placed on the casing head of each well using the above referred to datum of 804.1 feet above sea level. Deductions were made for all thicknesses above the base of the Chattanooga black shale (Devonian). The model structure produced is thereby pictured on the top of the underlying Devonian limestone or "cap rock," and the concep-


KENTUCKY GEOLOGICAL SURVEY.
SERIES VI 1921.
SKETCH MAP OF THE
CAMPBELLSVILLE GAS FIELD
TAYLOR COUNTY, KY.
BY W. R. JILLSON, STATE GEOLOGIST.
LEGEND
Gas Well
Abandoned Well
Anticlinal Crest
Post Office
0 1 2 MILES
SCALE
N
Hobson
Saloma
W.L. Hall
C.M. Hill
J.H. Hill
Pitman Cr.
A Campbell
Fork
Big Pitman Cr.
Bengo
Middle
Fork
Turner
East
Shiloh
CAMPBELLSVILLE
Davis
Wayne
Sulphur Well
Bailey
Russell
TAYLOR
GREEN
Cheney
W. Peniack
J. Larimore
A. Workman
L. & N. R.R.
J.W. Lloyd
Hatcher
COUNTY
COUNTY
Hubbard
A. White
C.R. Buchanan
I. Miller
GREEN
RIVER

tion is as if all of the rocks above this strata were removed and no drainage lines were established on the area involved at all.

The actual result of these investigations and detailed work is the definite recognition of a pronounced anticlinal fold with major axis running about north 80 east and situated about five miles west of Campbellsville. A reversal dip to the east of at least 17 feet is worked out and established. More extensive data extending farther to the east, could it be secured, might easily increase this reversal. This very desirable data will not be obtainable until a few wells are drilled a mile or so west of Campbellsville.

ONE SOURCE OF CAMPBELLSVILLE FUEL.
The view shows the J. R. Bailey No. 1, gasser, tubed and closed into the Campbellsville gas line. This well is reported to have an open flow of 2,500,000 cubic feet daily. It is located slightly southeast of the Wayne well and about five miles west of Campbellsville, Taylor County.

The Campbellsville anticline in its presently revealed form (which may be somewhat modified by further data resultant from additional drilling) is in its high points a north and south series of three domes. One of these domes lies in the vicinity and just south of Saloma, another near Sulphur Well, and a third is located to the south, near Green river. This last or southern dome cannot be thoroughly substantiated at present due to the insufficiency of the data secured on the White and Buchanan wells. However, there is much indirect evidence that leads to this summary conclusion.

The closure to the north on the northernmost dome near Saloma is probably small as noted by surface dips, insufficient drilling making a more accurate determination impossible. The change to the normal southwest dip is observable in proceeding north before the Marion county line is reached. On the middle and probably most perfect dome there is a rapid fall to the west of at least 100 feet in the three miles from the Bailey to the Turner well. In passing it may be well to note that one of these domes, possibly the middle one, may represent a cross fold with a southwestward prolongation of Linney's Kentucky Anticlinal which starts in Madison and Garrard counties as parallel nearly east and west faults and extends southwestward through Lincoln and Casey into Taylor as an unbroken fold.

Records of Drilled Wells.

Up to the present time about twenty oil and gas wells have been drilled in Taylor county, and about fifty in Green county. Of this number about twenty have been drilled within the area under consideration, including a few wells drilled just to the west of the Green-Taylor line in Green county. Tabulated data on most of the wells located within the area being considered are given herewith.

PARTIAL LIST OF DRILLED WELLS ON AND ADJOINING THE CAMPBELLSVILLE ANTICLINE.
TAYLOR COUNTY.

Lessor	Lessee	Location	Production Reported. Cu. Ft. Gas	Depth of Production	Total Depth
T. J. Smith	Wm. Leonard, et al.	Spurlington	Very small gas	450	475
T. J. Smith	Wm. Leonard, et al.	1½ mi. S. E. Spurlington	Dry	450	450
L. B. Smith & Co.	L. B. Smith & Co.	Campbellsville	99,000	350	356
J. W. Wayne,* now Carder	Green River Gas Co.		2,500,000	352–369	370
J. R. Bailey*	Green River Gas Co.	Near Sulphur Well	2,500,000	358–376	442
W. A. Russell*	Green River Gas Co.	1 mi. N. Wright Sta.	500,000	273–300	394
J. H. Hill*	Kenney Oil Co.	1 mi. E. Saloma	1,400,000	410–420	540
A. Campbell	Kenney Oil Co.	1½ mi. N. E. Bengal	500,000	745	775
W. T. Cowherd	Geo. Carson, et al.	1 mi N. W. Lorain	1,500,000	300	
W. L. Hall*	Kenney Oil Co.	1 mi. N. E. Saloma	Dry		437
C. M. Hill*	Kenney Oil Co.	¾ mi. S. W. Saloma	Dry		430
J. W. Cloyd	Green River Gas Co.	2½ mi. S. W. Campbellsville	Small gas, dry		553
I. K. Miller*	Green River Gas Co.		Dry		553
Van Dyke farm*	Green River Gas Co.		Dry		300
Leonard farm			Dry		2800
A. Hubbard			Dry		1200
Andy Lawler			Dry		276
Davis (Campbellsville)			Dry		1300

GREEN COUNTY

Lessor	Lessee	Location	Production Reported. Cu. Ft. Gas	Depth of Production	Total Depth
R. A. White	Green River Gas Co.	1 mi. S. Whitewood	3,420,000	210–229	229
C. R. Buchanan	Green River Gas Co.	1¼ mi. S. Whitewood	3,400,000		
W. Chaney	Green River Gas Co.	1½ mi. N. W. Whitewood	1,100,000	324–356	395
W. O. Penick	Green River Gas Co.	1 mi. N. Bluffboone	1,300,000	225–249	249
J. Larimore		¼ mi. W. Bluffboone	Shows of gas and oil	209	222
J. H. Kesler	S. W. Meals, et al	3½ mi. S. W. Greensburg	Oil show and salt water	293	298
J. E. Thompson			Very small oil		599
W. Turner			Salt water and small gas		365
J. Stereman			Dry		

(1) Amount of gas now giving daily in the Campbellsville line. About 240,000 cu. ft.

(2) Amount of gas produced in the Campbellsville field west of the city: Taylor County, 5,500,000 cu. ft.; Green County, 11,500,000 cu. ft.

(3) High, 39. Low, 38. Average rock pressure of individual wells. All wells about the same, 39 pounds.

LOGS OF OIL AND GAS WELLS DRILLED ON AND ADJACENT TO THE CAMPBELLSVILLE ANTICLINE IN TAYLOR COUNTY, KY.

Log No. 1.

J. W. Wayne, No. 1.
¼ mile N. W. of Sulphur Well P. O.

Strata	Thickness	Depth
MISSISSIPPIAN SYSTEM		
Soil	5	5
Lime gray	15	20
Blue shale	7	27
Lime gray	113	140
Flint rock	15	155
Gray lime	46	201
Lime (broken)	89	290
Blue shale	7	297
DEVONIAN SYSTEM.		
Black shale	50	347
Lime (cap)	5	352
Pay sand (gas)	17	369
Lime hard	1	370
Total depth		370

Reported production, 2½ mil. cu. ft. gas.
Casing head 790 ft. A. T.
Base of black shale 443 ft. A. T.

Log No. 2.

J. H. Hill, No. 1.
One mile S. W. of Saloma P. O.

MISSISSIPPIAN SYSTEM		
Soil	10	10
White lime (gas and water)	2	12
Brown lime and shale	173	185
Lime and green shale	15	200
Lime and brown shale	100	300
Green shale	30	330
DEVONIAN SYSTEM		
Black shale	70	400
White lime	10	410
White sand (strong gas)	10	420

Strata	Thickness	Depth
Brown lime	50	470
Green shale	15	485
Lime and shale	15	500
White lime	20	520
"Sand" (good and dry)	15	535
White lime	5	540
Total depth		540

Reported production, 2 million cu. ft. gas.
Tests: 1/26 gal. gas to 1000 ft.
Casing head 864 ft. A. T.
Base of black shale 464 (?) ft. A. T.

Log No. 3.

Annie Campbell, No. 1.
2 miles S. W. of Saloma P. O.

MISSISSIPPIAN SYSTEM

Soil	7	7
Brown lime	11	18
Lime and shale	52	70
Gray lime (gas)	10	80
White lime	5	85
Gray lime	55	140
Brown lime and flint	107	247
Brown lime	285	532
Oil sand (good sand and gas)	28	560
Lime and shale	25	585
Red fire clay	35	620
Red fire clay	65	685
White lime	25	710
Oil sand (good and dry)	20	730
Sandy lime	15	745
Brown lime	30	775
Total depth		775

Reported production, 500,000 cu. ft. gas.
Casing head 904 ft. A. T.
Base of black shale, 372 (?) ft. A. T.

Log No. 4.

C. M. Hill, No. 3.
¾ mile S. W. Saloma P. O.

Strata	Thickness	Depth
MISSISSIPPIAN SYSTEM		
Soil	20	20
Brown lime and sand	180	200
Brown lime and shale	45	245
White soapstone	25	270
Green shale	80	350
DEVONIAN SYSTEM		
Black shale	52	402
Brown lime	5	407
White sand (dry)	7	414
Brown lime and flint	16	430
Total depth		430

Reported production, dry
Casing head 884 ft. A. T.
Base of black shale 482 ft. A. T.

Log No. 5.

W. L. Hall, No. 4.
1 mile N E. of Saloma P. O.

MISSISSIPPIAN SYSTEM.		
Soil	20	20
Black lime and shale	50	70
White lime and flint	10	80
Brown lime and flint	5	85
Lime and flint	20	105
Gray lime	5	110
Lime and shale	20	130
Gray sand	5	135
Black shale	15	150
Gray lime	5	155
Black lime and shale	20	175
Gray and white lime	25	200
Gray lime	25	225
Brown lime and shale (gas)	40	265
Brown lime and shale	100	365
DEVONIAN SYSTEM.		
Black shale	10	375
Black shale	35	410
Gray lime	8	418

Strata	Thickness	Depth
Sand (neither oil nor gas)	12	430
Brown and gray lime	7	437
Total depth		437

Reported production, dry.
Casing head 954 ft. A. T.
Base of black shale 544 (?) ft. A. T.

Log No 6.

J. R. Bailey, No. 1.
Just south of Sulphur Well P. O.

MISSISSIPPIAN SYSTEM.

Soil	3	3
Lime, gray	140	143
Blue shale	2	145
Lime, white	2	147
Gray lime	84	231
Lime (broken)	60	291

DEVONIAN SYSTEM.

Black shale	52	343
Cap (lime)	3	346
Corniferous L. S. (gas)	30	376
Blue and pink shale	55	431
Lime, gray	2	433
Lime (brown sand)	4	437
Shaly sand	5	442
Total depth		442

Reported production, 2½ mil. cu. ft. gas.
Casing head 790 ft. A. T.
Base of black shale 447 ft. A. T.

Log No. 7.

W. A. Russell, No. 1.
¾ mile S. E. of Sulphur Well P. O.

MISSISSIPPIAN SYSTEM.

Lime (gas)	115	115
Lime (gas 160)	50	165
Blue shale	5	170
Lime	40	210
Gray shale	10	220

Strata	Thickness	Depth
DEVONIAN SYSTEM.		
Black shale	40	260
Lime, soft	10	270
Pay gas	30	300
Blue and red shale	50	350
Brown sand	44	394
Total depth		394

Reported production, 500,000 cu. ft. gas.
Casing head 690 ft. A. T.
Base of black shale 430 ft. A. T.

Log No. 8.

Record of J. W. Cloyd, No. 1.
Location, 2½ miles S. W. of Campbellsville.
Began drilling September 1, 1920.

Strata	Thickness	Depth
MISSISSIPPIAN SYSTEM.		
Sandy clay	3	3
Hard brown lime	100	103
Gray lime	25	128
Soft brown lime	132	260
Blue shale and gumbo (steel line measure)	30	290
DEVONIAN SYSTEM.		
Black shale	32	322
Brown shale, dark	11	333
Cap rock (steel line measure, rainbow show of oil)	½	333½
White lime	2½	336
ORDOVICIAN SYSTEM.		
Soft blue shale	27½	363½
Soft brown shale (pink)	3¾	367¼
Brown (sand?) lime	4¼	371½
Brown lime	33½	405
Pale yellow sand	10	415
White lime	3	418
Broken lime	22	440
Brown lime	57	497
Total depth		497

Reported production, salt water.
F. L. Parrott, Contractor.
Walter Hobson, Finn Litrell, Drillers.

Oil and Gas Summary.

Of these twenty wells about ten, or half, are of commercial importance as gassers, varying in size according to report from 100,000 cubic feet to 2,500,000 cubic feet per day open flow when first drilled in. While the volume of many of these wells is large, the rock pressure of all of them as reported is uniformly low, ranging between 38 to 40 pounds, and with an average of about 39 pounds. In all this drilling, there is not a single commercial oil well, and none of these wells according to reports gave any indication of being drilled in close proximity to oil territory.

A HIGH STRUCTURE GASSER.

The J. W. Wayne No. 1, gasser, producing a reported 2,500,000 cubic feet daily open flow when flush, was drilled close to the crest of the Campbellsville Anticline. It is connected to the city's main gas pipe line.

The situation is therefore somewhat peculiar. The writer does not find any reasonable explanation for this large amount of gas and apparent absence of oil, unless it be due to the fact that there is an insufficient amount of water. A lack of water in the "pay sand" (really a limestone) would of course make it impossible for the oil to occupy a subjacent position to the gas of either medium or large volume. And the lack of water generally to fill the syncline, especially on the down-dip side, seems to be established somewhat by the very low rock pressure of this field. It is difficult to conceive or to name a gas field with normal or ideal water conditions existing where a rock pressure of from four to ten times that of this field would not be found in practically any well.

If this theory of insufficient water were to be accepted, it would only be reasonable to expect that some oil would be encountered on the up-dip or east side of the structure, yet the few wells which have been drilled in here, although they do not completely test out this prospective section, give no promise of an area of oil accumulation. Further prospecting of the area between Campbellsville and the gassy or high structural area to the west is therefore recommended. It is quite possible that this region which is undrilled may hold the key to the successful oil development of this anticline and Taylor county.

XIII.

PAINT CREEK—PIRATE.

Modifications of the drainage lines of many of the minor streams in the hill or "Mountain" section of Eastern Kentucky are not uncommon. The careful observer riding up and down the creeks of this portion of the State will not fail to note, and find much interest in, the occasional "low pass" or "wind gap" left here and there in the uniformly steep ridges like a great topographic blaze to mark the former pathway of a watercourse. Yet in a section of such intricate dendritic drainage as that of the eastern part of this State, it must not be assumed that the simple occurrence of the essential low pass or "wind gap" is in itself sufficient criteria to establish stream piracy. Quite the contrary is the actual case. Coupled with the lowered divide there are many other hydrogeological factors that necessarily enter into each specific case and operate to completely substantiate and prove the actual occurrence of the modification. Where such factors are lacking or fail to nicely adjust themselves to reasonable explanation, the hypothesis of diversion is, of course, untenable.

While engaged in various geological field excursions into Floyd, Johnson, Magoffin and Morgan counties in Eastern Kentucky during the past few years, the writer has become much interested in unraveling the factors involved in several very evident instances of stream piracy.* The individual problems thus encountered have not, however, always lent themselves to simple solution. In some cases there have been overlapping piracies. In the one presently to be described on the headwaters of Paint Creek, in Johnson, Morgan and Magoffin counties, complex structural influences as well as double capture have operated hand in hand with a varying lithology to quite effectually mask for a time the orderly sequence and evaluation of the causal factors.

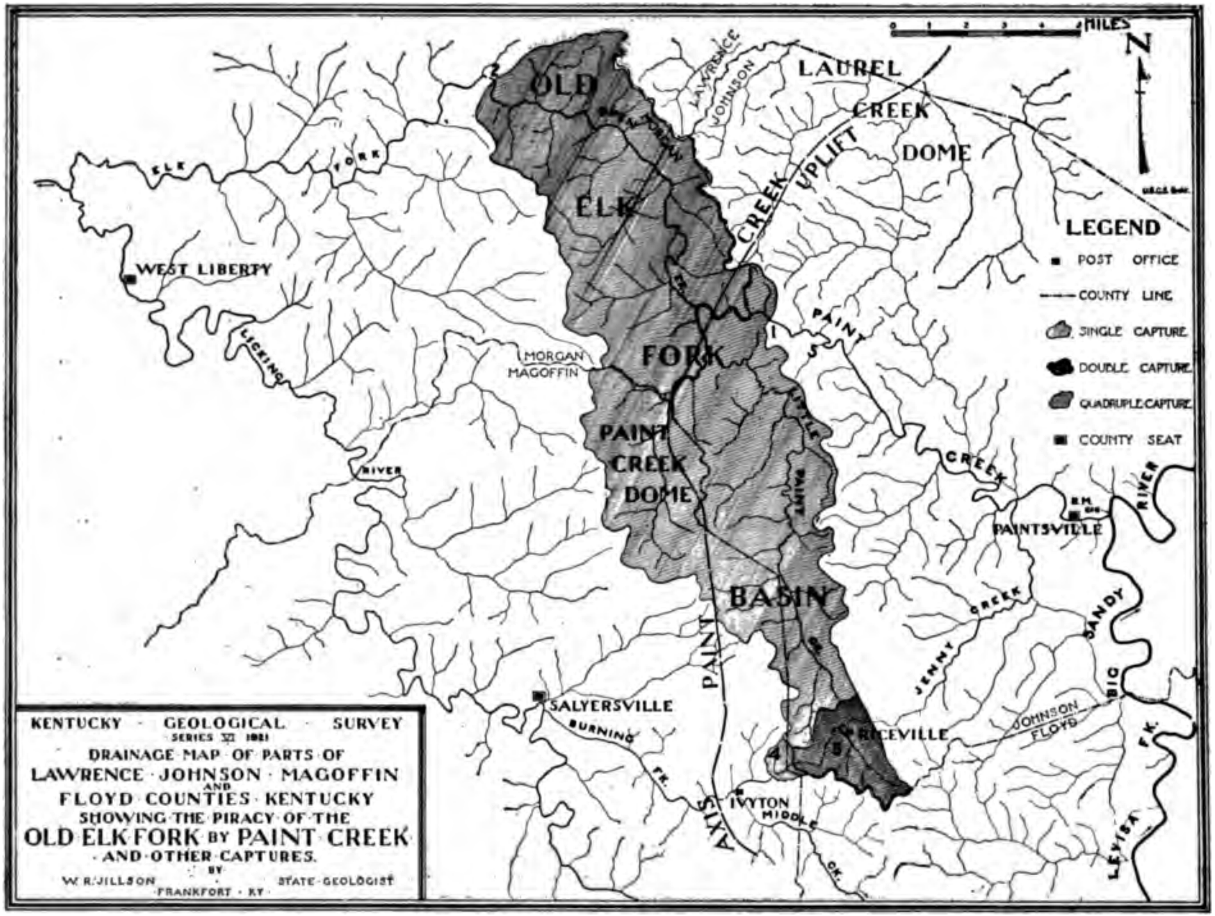
*Jillson, W. R., Migration of the Headwaters Divide of Right Middle Creek, Floyd County, Kentucky. Pub. in Contributions to Kentucky Geology, Dept. of Geol. & Forestry of Ky., Series V, Bull. IV, pp. 65-70. 1920. Also Am. Jour. Sc., Vol. XLVII, pp. 60-64, Jan., 1919.

The direction of flow of the principal drainage of the Cumberland plateau of eastern Kentucky is to the north or northwest. This is true of the Big Sandy, the Licking, and the Kentucky rivers and their main tributaries. The gradually increasing elevation of this plateau region from the Ohio river debouchures of these streams to their headwaters in the Cumberland Mountains to the southeast indicates clearly that this north or northwest direction of flow may be satisfactorily explained by the great crustal uplifting of this broad region in post Paleozoic times.

Speculative conceptions of the geologic periods of broad regional emergence and peneplaination of this plateau area, however, may be disregarded in this discussion, because of the relatively small unit of drainage of the Big Sandy and the Licking river under consideration. It will be well to understand, nevertheless, that the latest faulting and folding of this part of Kentucky, now mappable on Pottsville Coals and the top of the Pottsville Conglomerate, has certainly had its modifying effect on the drainage courses major and minor. Instances of extensive meanderings are plainly visible in this region

PAINT CREEK GORGE ON BIG PAINT CREEK.

The view is near Manila post office, Johnson County, and shows the Irvine-Paint Creek fault in the distance. The cliffs exposed in the foreground are on the upthrow side.



SKETCH MAP OF THE PIRACY OF OLD ELK FORK BY BIG PAINT CREEK.

Explanation: 1. Original headwaters of Paint Creek and locality of first capture. 2. Fannin Gap. Present westward migrating headwaters of Paint Creek. 3. Jenny Creek double capture of the Little Paint headwaters. 4. Quad-

on the up or impounded sides of practically all large and small streams crossed transversely by large anticlines of faults.

On the Johnson-Morgan county line in eastern Kentucky there occurs in the gorge-cut main channel of Big Paint Creek at its juncture with Little Paint Creek a very unusual drainage figure for a section that is typically dendritic. The Open Fork of Big Paint Creek flowing down from the northwest, meets Little Paint Creek uowing to the northwest. The Open Fork is about ten miles long in an air line, and Little Paint Creek is about fourteen miles long i nthe same measurement. The creeks unite, and turning slightly to the east from the mouth of Little Paint Creek continue on to the southeast as Big Paint Creek, which joins the Levisa Fork of the Big Sandy river just east of Paintsville. The angle of juncture of Little Paint Creek with Big Paint Creek is 35° against the current of the larger stream, and is therefore contrary to normal dendritic drainage.

A glance at the outline map accompanying this paper will serve to throw light on the correct placements of these several streams. A detailed examination of the Paintsville (1-62,500) and Salyersville (1-125,000) Kentucky U. S. G. S. topographic sheets from which this map was produced will serve to further clarify the exact situation. It will be noted that the drainage basins of Little Paint Creek and the Open Fork when taken together are in reality a unit and easily conceivable to have been in not too remote geologic time an integral part of the drainage of the Elk Fork of the Licking river. Paint Creek is seen to have been at that time a rather short wedge-shaped minor drainage basin naturally resultant to the very sharp turn to the northeast of the Levisa Fork of the Big Sandy river near the Paint Creek debouchure.

Data obtained in the field and from a study of the maps of the region operating to substantiate these summary conclusions of drainage modifications in the channel of Big and Little Paint Creeks, the Open Fork of Paint Creek, and the Elk Fork of the Licking river, are as follows:

(1) Little Paint Creek empties into Big Paint Creek at an angle of 35° against the current of the major stream in a section of typically dendritic drainage, thus establishing an abnormal condition.

(2) The small branches tributary to Big Paint Creek attain their most minute and right angled figure between the Elna and Fuget post offices, Johnson county, where they are scarcely over a mile long. The evident constriction of the Big Paint drainage basin in this locality indicates that the headwaters of Big Paint Creek formerly existed along some irregular line within this area.

(3) The present occurrence of a "near piracy" in the low pass to be found in Low Gap Branch from Big Paint Creek to Little Paint Creek is a striking suggestion of the method of operation of this drainage modification. It is also an instance of how close the Low Gap Branch head-ward erosion came to Creek. The importance of this confirmatory evidence is greatly being the factor of real capture and later the bed of Big Paint intensified by the field examination.

(4) Low water at the mouth of Elk Fork and the Licking River in Morgan County is about 790 feet above tide. Low water at the mouth of Big Paint Creek and the Levisa Fork of the Big Sandy River in Johnson County is about 590 feet. This gives a difference of elevation of 200 feet between the mouths of these two minor competing streams. It is altogether reasonable that this present difference of drainage levels has been rather consistently maintained through the life history of these streams, since the Licking river at the mouth of the Elk Fork is approaching its headwaters, while the Levisa Fork of the Big Sandy river is more than half way down its course at the mouth of Big Paint Creek. This 200 feet of difference of drainage in the two minor streams has during the most recent period of erosion given the principal stimulus to the headward cutting of the headwaters of Big Paint Creek.

(5) At the head of the Open Fork of Big Paint Creek occurs a low gap or pass over into Fannin's Fork of Elk Fork. This gap with an elevation of 950 feet above tide is the lowest in the whole country side. The ridge elevations in this vicinity are from 1200 to 1300 feet, while the actual drainage a quarter of a mile from the gap on either creek is about 880 feet above tide. Erosive agents are now rapidly at work on the Open Fork (Big Sandy drainage) from the gap to the lower reaches of Big Paint Creek. The hills of the Open Fork are high, and the valley narrow with very little bottom. On the Fannin Fork

SYLVAN SOLITUDE.

There are many quiet and secluded reaches in the gorge of Big Paint Creek where fine fishing holes may be found, or good squirrel hunting enjoyed. Pirate though she is, Paint Creek, especially in her upper reaches, is one of the most enjoyable companions for the nature lover who may be blessed with "a day off!"

side (Licking drainage) the erosion is much slower, the stream small as compared to its valley, which is broad and flat, giving every indication of lack of present adjustment. The drainage of the Open Fork is evidently reversed since practically all of the branches come into the main channel at an actue angle against the current. The Open Fork-Fannin Fork gap is without doubt the point of present modification, and indicates again the usual method of migration of the drainage divide in this part of the Cumberland Plateau.

(6) The drainage courses of Little Paint, the Open Fork, and Big Paint Creek all show evidences of more or less modification and adjustment to the structure as mapped on the Pottsville. The Little Paint Creek or headwaters portion of the Old Elk Fork lies on the east side of the major axis of the Paint Creek uplift. The Open Fork or middle segment of the Old Elk Fork lies on the west of the same structural high. Big Paint Creek, north of the Irvine-Paint Creek Fault, lies in a pronounced syncline between the Paint Creek and Laurel Creek domes of the principal uplift. The result of the folding and faulting of the Pottsville sediments of the Paint Creek uplift was: (1) to arrest with the Paint Creek dome the erosion on the headwaters of Little Paint Creek; (2) to stop erosion near the Little Paint-Open Fork juncture on both creeks due to its developing synclinal position; (3) and at the same time due to the general regional uplift and its fortunate synclinal channel to assist Big Paint Creek in its headward erosion and ultimate piracy of the waters of Little Paint Creek and a portion of Open Fork just west of Elna. The completion of the Open Fork capture from this point on was simply a matter of sufficient time for headwaters migration to the present position of the Fannin Gap.

(7) The present headwaters of Little Paint Creek is the Green Rock Fork just north of Riceville in southern Johnson county. There is much unquestionable evidence to be found in the Riceville section, however, indicating that Long's Creek and the Narrows, now tributaries of Jenny Creek (left fork Paint Creek), were in the recent past the actual heads of the Elk Fork-Little Paint Creek tributary of the Licking river. There is evidence here of the rather unusual instance of a

double capture effected by competing forks of Big Paint Creek, on an adjoining tributary, Little Paint Creek, then the Old Elk Fork of the Licking river.

(8) In the further and recent capture by the Narrows Fork (Jenny Creek) of the small Pound Branch just west of the Johnson-Magoffin county line there is instanced without doubt a case of quadruple piracy, that is, one in which four separate stream captures are involved. This is indeed a very rare occurrence, and the first that has come to the writer's attention. To fully appreciate the situation one must understand the drainage history of the Burning Fork of the Licking River and Middle Creek, a Big Sandy river tributary. It has been shown* that the Ivyton drainage of Middle Creek was captured from the Burning Fork. This Ivyton drainage at that time included the Pound Branch, as all field criteria indicate. The Middle Creek capture was the first, the diversion of the Riceville drainage to Jenny Creek involved the second and third piracies, and the final capture by the Narrows Fork, a Jenny Creek-Paint Creek tributary, of Pound Branch, at that time a Middle Creek headwaters tributary, brings in the fourth separate capture in sequence that is involved in this case.

Summarily, there is humor in this series of drainage complications. Big Paint Creek is seen in the role of a real pirate, stealing from her less aggressive neighbor, the Old Elk Fork, something like 100 square miles. The first large piracy was to the south (Little Paint Creek), and then later slowly but surely to the north (Open Fork). In her thieving caprices, however, Paint Creek has shown a certain lack of efficiency. It may be that with her pirating hands behind her back, she did not let the right one know what the left was doing. Or perhaps those westward-reaching arms stole for the love of stealing. At any rate when Jenny Creek captured the headwaters of the Old Elk Fork near Riceville, it simply rediverted the drainage on about five square miles of the headwaters of the Old Elk Fork, which had already been captured just west of Elna post office by the Right Fork or Big Paint Creek. As a result of this double piracy, the waters now falling in the vicinity of Rice-

*Op. Cit.

ville find their way down Jenny Creek into Big Paint Creek, and thence to the Levisa Fork of the Big Sandy River. Such waters, however, though twice captured, do not increase the size of the main Paint Creek over the increment obtained in the original—Elna—capture.

Manuscript completed Mar. 1, 1921.

Finis

INDEX

ALPHABETICAL ARRANGEMENT OF SUBJECT MATTER AND AUTHORS.

D.

E.

F.

G.